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Knowledge sharing for sustainable development: A mixed-method study of an international civil engineering consultancy

Meese, Nicholas

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KNOWLEDGE SHARING FOR SUSTAINABLE DEVELOPMENT: A MIXED-METHOD STUDY OF AN INTERNATIONAL CIVIL ENGINEERING CONSULTANCY

NICHOLAS C. MEESE

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ABSTRACT

Sustainable development (SD) is a pressing global issue that is becoming increasingly prominent on clients and governing bodies agendas. In order to survive, organisations are seeking ways to negate their detrimental environmental impacts. This is no easy feat: SD is both complex and dynamic. To be successful, organisations need to leverage and expand their most valuable asset – knowledge.

Civil engineering plays a significant role in SD – it shapes our environment and governs our interaction with it. However, extant research asserts that civil engineering related disciplines have been slow to adopt SD oriented practices; a possible result of their complex and fragmented organisational environments. The literature suggests that effective knowledge sharing (KS) can overcome these barriers, thus driving enhanced SD performance. Consequently, this research aims to investigate how the civil engineering sector can improve its intra-organisational sharing of SD knowledge, using an international civil engineering consultancy as an exemplar. Whilst there has been much research surrounding KS and SD there has been limited research that has investigated KS *for* SD, thus this thesis contributes to this limited body of knowledge.

Mixed-method research was used to address the abovementioned aim. An increasingly popular approach, it is widely believed to generate greater value through complementary integration of quantitative and qualitative research paradigms. This approach lends itself also to the ethnographic inclinations of the reported research: the author was embedded within the case organisation, and sought a rich and reliable understanding of the study phenomena.

An initial set of semi-structured interviews suggested that the case organisation's members exhibit positive attitudes towards KS and SD, yet are often constrained by a number of common KS barriers, namely: a lack of organisation slack (i.e. time); a silo mentality; and poor SD ICT systems. These socio-cultural and technical barriers were subsequently investigated and contested using social network analysis techniques and an intranet acceptance model.

A number of observations are made on the relationships between the findings from the research activities. It is believed the organisation often exhibits a reactive approach to KS for SD, which is deemed undesirable. This signals the need for greater senior management support to cultivate a culture where KS for SD is the

norm and is integrated with work practices. A series of recommendations are provided to help the case organisation understand how such change could be cultivated.

Several implications follow from this work. The mixed-method approach revealed a number of contradictions between the findings of each research activity. It is therefore postulated that mixed-method designs can provide a richer understanding, thus reducing misconceptions of KS phenomena. Following from this, the research contends that it may be too easy for researchers to identify with ubiquitous KS barriers as the reported research suggests that these may be perceived rather than actual. The research also reinforces the need for senior management support. These individuals govern the systems in which organisational members operate and thus have the ability to enhance KS for SD. Finally, the research demonstrates that SD ICT systems have little impact unless they are embedded in receptive contexts. Thus, an action research approach to KS system development is advocated to ensure systems are shaped to meet user expectations and drive desired KS behaviours.

This research is presented in five peer-reviewed articles.

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LIST OF ABBREVIATIONS

AVE	*Average Variance Extracted*
CCA	*Constant Comparison Analysis*
CKO	*Chief Knowledge Officer*
CoP	*Community of Practice*
EK	*Explicit Knowledge*
EngD	*Engineering Doctorate*
EPSRC	*Engineering and Physical Sciences Research Council*
HRM	*Human Resource Management*
IAM	*Intranet Acceptance Model*
ICT	*Information Communication Technology*
ISO	*International Organization for Standardization*
IT	*Information Technology*
KM	*Knowledge Management*
KMS	*Knowledge Management System*
KS	*Knowledge Sharing*
KT	*Knowledge Transfer*
MBF	*Macro Business Function*
PLS	*Partial Least Squares*
QDA	*Qualitative Data Analysis*
SC	*Social Capital*
SD	*Sustainable Development*
SECI	*Socialisation, Externalisation, Combination, Internalisation*
SG	*Skill Group*
SE	*Subject Expert*
SEM	*Structural Equation Modelling*
SN	*Social Network*
SNA	*Social Network Analysis*
TAM	*Technology Acceptance Model*
TK	*Tacit Knowledge*
UK	*United Kingdom*
UoB	*University of Bath*
VBA	*Visual Basic for Applications*
VC	*Video Conference*

CHAPTER 1
INTRODUCTION

This chapter introduces the research programme. It provides an overview of the subject domain and the industrial sponsor. The overarching aims and objectives are then introduced, along with the justification for the research. It concludes with a descriptive outline of the thesis and a summary of the peer-reviewed articles that were reported in the wider research community.

1.1 SUBJECT DOMAIN

Our planet is placed under increasing strain as the global population is on target to reach seven billion occupants in 2011 (Kunzig, 2011). Such a large population has resulted in the consumption and depletion of natural resources that increasingly outweighs what is sustainable in the long term. Consequently, the human race is now facing critical survival issues. In response, much research has been conducted in the field of sustainable development (SD), which ultimately aims to minimise our ecological footprint whilst allowing economic and social development to continue.

Unfortunately, it is contended that most SD research and practice consists of rhetoric rather than concrete examples of how SD can be achieved (Boyle and Coates, 2005). Conversely, the author believes the lack of 'concrete examples' to be principally due to the complexity and uncertainty surrounding the notion of SD (Seiffert and Loch, 2005, Atkinson, 2008, Chaharbaghi and Willis, 1999). It has been proposed that knowledge and information sharing would enable SD to move beyond the rhetoric to deliver holistic sustainable solutions (Curran, 2009, Sage, 1999).

Civil engineering related sectors process vast quantities of natural resources to create and maintain our habitats and infrastructures; e.g. the United Nations Environment Programme (UNEP, 2007) reported that the building sector alone is accountable for 40-50% of total world raw material consumption. Furthermore, these habitats and infrastructures largely govern how we interact with our environment (Shelbourn et al., 2006), thus affecting the degree to which we can exhibit sustainable behaviour in our day-to-day lives. Consequently, civil engineering plays a vital role in the advancement and application of SD practices, such as: design for recyclability; energy efficient buildings; improved public transport networks; and so on.

Sadly, civil engineering related disciplines have, by and large, been slow to adopt SD practices (Boddy et al., 2007); a possible result of their complex and fragmented nature (Myers, 2005). However, commitment to SD is presently in vogue, generating enthusiasm to adopt SD practices in civil engineering organisations (MHC, 2008). Consequently, civil engineering oriented SD philosophies and practices are rapidly evolving, where ideas and innovations often quickly become out dated.

Knowledge is vitally important when grappling with the complex and uncertain nature of SD. As such, many organisations have been exerting considerable effort to leverage knowledge assets (i.e. intellectual resources; e.g. know-how, know-who) with the aim of closing SD knowledge gaps (e.g. Mohamed et al., 2009). This resonates with a recent study of over 1,300 business professionals, 65% of whom placed value on personal SD knowledge (e.g. when hiring new candidates) and 78% believing personal SD knowledge will increase in importance by 2014 (Gullo and Haygood, 2009). Whilst extensive research and education programmes were attempting to meet the prevailing demand for SD knowledge, it seemed by comparison little had been done to encourage the cross-boundary sharing of such knowledge. For SD knowledge to be truly effective it needs to be mobilised across disciplinary, organisational and geographic boundaries, thus allowing individuals to share and capitalise on their knowledge assets and to respond to shifting SD requirements. If knowledge is not sufficiently mobilised, it is possible that we will fail to innovate and adapt fast enough to systematically enhance the way we interface with our ever degrading environment.

1.2 THE INDUSTRIAL SPONSOR

The industrial sponsor wished to remain anonymous throughout the research. It is an international civil engineering consultancy with an annual turnover in the order of €500 million, roughly half of which is generated in the UK. At the point the research programme commenced it housed a staff base of several thousand, though this was significantly reduced by the end of the programme due to economic hardship brought about by the recession experienced during 2008-09 (cf. Monaghan, 2010). The organisation imposes a functional hierarchical structure designed to accommodate macro business functions (MBFs) (e.g. property development, transport infrastructure), which were served by specialist skill groups (SGs) (Figure 1.1). SGs bid for and deliver client projects independently and collaboratively with other SGs. Technical organisational members are commonly educated at a

university level, and regularly progress to attain professional certifications. Work environments are often open-plan to encourage professional interaction, with most offices boasting hot-desking facilities for visitors. Dress code is smart but ties are not compulsory.

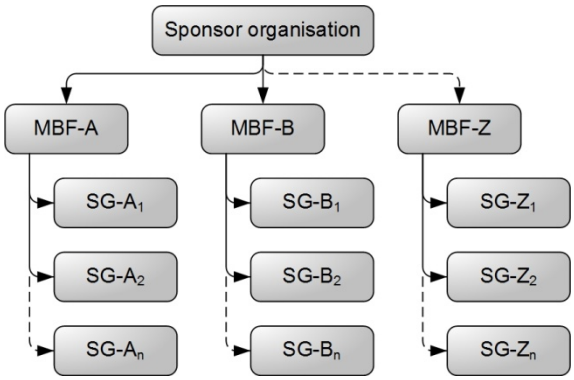


Figure 1.1. Sponsor organisation's hierarchical structure

The organisation's ethos is founded in social and environmental sustainability and subsequently these are a core aspect of its strategy. To ensure its sustainability agenda is implemented, two senior sustainability leaders had been appointed to oversee sustainability activities. One leader is responsible for internal sustainability operations (e.g. sustainability project assessment, office operations, and so on), whilst the other is responsible for strategic development and interfacing with relevant external bodies (e.g. Forum for the Future (FftF, 2010), Green Buildings Council (UK-GBC, 2010). These dedicated individuals underpin a strategic task force that consists of sustainability representatives from each macro business function. Meeting each month, task force members share a holistic understanding of sustainability within the organisation (e.g. initiatives, innovations, market conditions, client requirements), whilst also acting as a platform for disseminating information and orchestrating programmes. Interestingly, there is a conscious decision not to formalise an organisational definition of *sustainability* or *sustainable development*. This is to prevent the organisation becoming too rigid or constrained within the confines of such a definition, and to ensure agile alignment with stakeholders' specific SD perceptions and needs. As such, the organisation defines *sustainability* through consultation with each client. Further, the organisation had also enlisted another EngD candidate to research sustainability assessment systems.

As a consultancy, the organisation operates solely in the knowledge economy[1]. To help it manage its knowledge assets, the organisation has a chief knowledge officer (CKO) who leads a small knowledge management (KM) team. However, whilst the organisation reinforces the importance of knowledge sharing (KS) in its strategy, the organisation does not have a formal KM strategy. Nevertheless, it uses a number of social and technical knowledge management systems (KMS). Social KMSs comprise of interpersonal activities, such as: working groups (known also as communities of practice); lunchtime seminars; training programmes; and mentorship programmes. A group-wide intranet system regularly forms the basis of the technical KM systems; however, built on simple HTML and ASP code, it did not exhibit the dynamic decentralised capabilities of more modern social platforms (e.g. Web 2.0). Besides hosting a high volume of informative hyperlinked intranet pages organised in line with the organisational structure, the intranet system also provides a number of dedicated KMSs, including: a SD portal; a skill search database; and a discussion forum. Performance can vary significantly between the various KMSs and their users. For example, in a study conducted outside the scope of this thesis, the author found that despite the discussion system being devoid of functional and geographic barriers, its users were predominately UK centric; it was also recognised that a small number of SGs were engaging in discussions markedly more frequently than most.

1.3 RESEARCH QUESTIONS, AIMS AND OBJECTIVES

The purpose of this research was to allow the author to learn why the SD performance of the civil engineering sector is seemingly poor and how the sector's enormous impact on all facets of SD can be reduced through greater organisational understanding of SD. As such, the founding research question was: "How can knowledge about SD be more effectively propagated in a civil engineering environment?" This generated further questions, such as: "How is SD knowledge currently propagated in civil engineering organisations?", "What are the key barriers to propagating SD knowledge in civil engineering?", and "What can be done to enhance the propagation of SD knowledge in civil engineering?"

[1] The term 'knowledge economy' refers to an advanced economic model whereby wealth is principally generated by "production and services based on knowledge-intensive activities … The key components of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process, from the R&D lab to the factory floor to the interface with customers." (Powell and Snellman, 2004, Brinkley, 2006)

To address these questions The principal aim of the research programme was to investigate enablers and barriers to sustainable development knowledge sharing within the civil engineering sector, using the sponsoring organisation as an exemplar, and to identify opportunities for enhanced performance. To achieve this aim the following overarching objectives were established during the early stages of the research programme in consultation with the sponsoring organisation:

- Review existing KS for SD literature in the field of civil engineering;
- Explore intra-organisational KS for SD within civil engineering contexts, using the sponsoring organisation as an exemplar; and
- Provide recommendations for how KS for SD performance may be enhanced within the sponsoring organisation and wider civil engineering community.

The above objectives were tackled using an exploratory case study research design that used a mixed-method approach to improve the validity and reliability of the findings. Each of the objectives was fulfilled via a series of sub-objectives, which were somewhat influenced by the findings from the previous research activities. Figure 1.2 provides a roadmap of undertaken research activities and how they support each other; Table 3.3 provides a more detailed summary of each activity's aims, objectives, research methods and key findings.

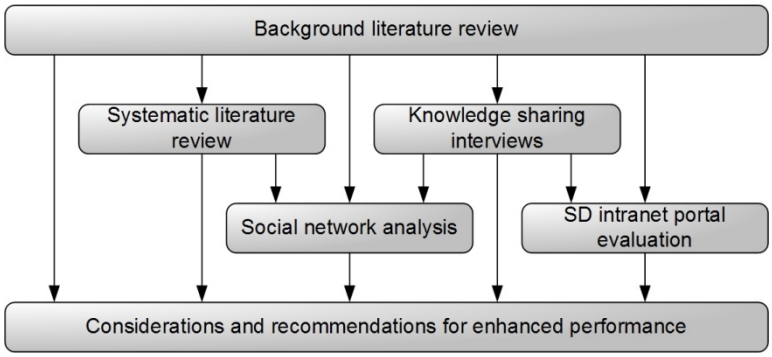


Figure 1.2. Research roadmap

1.4 JUSTIFICATION AND SCOPE

As expressed above, SD is necessary to alleviate the increasing stress placed on our planet's finite resources and delicate ecosystem without detriment to our economic and social systems. Whilst this is no easy feat, effective KS may help lower technical SD barriers, thus catalysing progression. However, whilst there has been much research surrounding KS and SD, there has been limited research that has investigated KS *for* SD; it is noteworthy that other facets of knowledge management

have been researched in relation to SD, e.g. the codification of knowledge for decision support. The lack of KS for SD research is especially true in the context of civil engineering. Consequently, this research programme contributes insight and understanding to an area that has received little direct attention.

The research presented in this thesis investigates KS for SD within the sponsoring organisation; this was deemed an important aspect of their organisational and SD strategy. Initial anecdotal evidence suggested that the organisation's KS issues stemmed from its size and its difficulty drawing on existing internal knowledge. As such, it was agreed between the author and his industrial and academic supervisors that the research programme would seek an understanding of the enablers and barriers to KS for SD within the organisation, with the goal of providing recommendations for improvement.

1.5 STRUCTURE OF THE THESIS

In addition to this introduction, this thesis comprises of four main chapters. It begins by reviewing the existing body of knowledge in relation to: the theory of knowledge; knowledge management; knowledge sharing; sustainable development; and civil engineering. Next, a number of research paradigms and common designs are presented, with a case study design being adapted from the civil engineering management literature. Chapter 4 then details the research programme, including the development, deployment, findings and discussion of the research instruments, as reported in the peer-reviewed articles. The concluding chapter presents a discussion on the relationships between the key findings of the research programme, the overall conclusions of the research, a series of recommendations to counter the observed issues, and a critical evaluation of the research.

1.6 SUMMARY OF PEER-REVIEWED ARTICLES

Table 1.1 provides a summary of the peer-reviewed articles emanating from this research. Full-text articles are located in the stated appendices.

Table 1.1. Summary of peer-reviewed articles

Appendix	Title	Journal/ Conference	Status	Description
A	Knowledge sharing in sustainable development: a systematic review	AI & Society (*Springer*)	In press	This article concentrates on KS for SD research in the civil engineering domain. Using a systematic review methodology, relevant peer-reviewed published studies are identified, categorised and discussed.
B	Barriers to sustainable development knowledge sharing in an international civil engineering consultancy	Construction Management and Economics (*Taylor & Francis*)	In review	This article reports the findings from a grounded theory analysis of a series of semi-structured interviews. Three KS for SD barriers were identified: a lack of organisational slack; poor ICT systems; and a silo culture.
C	Analysing sustainable development social structures in an international civil engineering consultancy	Journal of Cleaner Production (*Elsevier*)	Published	This article uses social network analysis (SNA) to explore SD knowledge and information sharing relationships. It was found that two previously identified KS for SD barriers did not generally hamper KS relationships.
D	Investigating barriers to knowledge and information sharing in sustainable development	International Conference on Product Lifecycle Management (*Bremen, Germany*)	Published	This article presents an overview of the research programme, with respect to providing knowledge and information support on sustainable development issues to civil engineering consultants. Observations are made on the enablers and barriers in improving organisational awareness of existing sustainable development practice.
E	Addressing data collection problems in web-mediated surveys	ASME 2010 International Computers and Information in Engineering Conference (*Montreal, Canada*)	Published	This article reports on a follow-up telephone survey in response to a web survey which received a poor response rate. It provides insight into the reasons behind the poor response, and practical guidance on how to improve response rates based on the findings and good practice from the literature.

CHAPTER 2
LITERATURE REVIEW

The purpose of this chapter is to survey the existing body of knowledge surrounding the key topics of this thesis. Its aim is to provide a foundation for the research undertaken, whilst identifying research needs and gaps within the existing body of knowledge. As such, a comprehensive review of the academic and industry literature was undertaken and is presented in the following sections.

The first section addresses the notion of knowledge, and considers the differences between individual and organisational knowledge. Next, a brief history of KM is provided, along with a series of definitions. KS, arguably the most important component of KM, is subsequently introduced by considering a series of definitions, organisational benefits and barriers, and its underpinning components that often play a major role in determining its effectiveness. Fourth, the need for sustainable development is addressed alongside a discussion of its fuzzy and complex nature; consideration is also paid to how KS can improve SD performance. An overview of civil engineering is then presented, considering the discipline in relation to the SD and KS research. The penultimate section reports on a systematic literature review which was undertaken to identify existing KS for SD research that exhibits a civil engineering context. The chapter concludes by summarising the key literature findings, highlighting a gap in existing knowledge and, thus, the need for the work reported in this thesis.

2.1 KNOWLEDGE

Epistemology, the philosophical theory of knowledge, has been debated by philosophers since Socrates (Jashapara, 2007). The notion of knowledge, its various forms, and the creation of organisational knowledge are addressed in this section.

2.1.1 The Data, Information and Knowledge Hierarchy

Probst et al. (1999) propose that there aren't sharp distinctions between data, information and knowledge; instead there are a great many steps where distributed symbols come together to form cognitive patterns on which decisions can be based. In this sub-section we briefly review each category in turn.

Data is frequently defined as a set of discrete objective facts relating to a set of events, or simply the structured record of a transaction (Clarke and Rollo, 2001,

Davenport and Prusak, 2000, Joia, 2000, Tiwana, 1999). Various other authors, such as Probst et al. (1999), suggest that data is unstructured, only consisting of symbols (e.g. zeros and ones); the author, however, believes structure is a prerequisite for data to be systematically processed, otherwise it would simply be noise.

Information is patterned data; it's been shaped and formed to give meaning and purpose (Clarke and Rollo, 2001, Davenport and Prusak, 2000, Joia, 2000). A measure of information is its usefulness (Marakas, 1999, p. 240). Thus, it is the recipient of the information who decides whether it is truly information or purely noise (i.e. whether or not it changes the receiver's perceptions) (Davenport and Prusak, 2000).

Definitions of knowledge are continuously contested throughout the literature by epistemologists and alike (Fernie et al., 2003, cf. Zins, 2007); for example, knowledge to one person may be perceived as information to another (Bhatt, 2002). However, one common perception is that knowledge is highly subjective – it is the interpretation, not representation, of an objective reality (Bellini and Canonico, 2008). Nonaka and Takeuchi (1995) endorse Plato's formulation of knowledge as "justified true belief", which resonates with the subjectivity that encompasses knowledge; "an individual justifies the truthfulness of his or her beliefs based on observations of the world; these observations, in turn, depend on a unique viewpoint, personal sensibility, and individual experience" (Von Krogh et al., 2000).

Many authors emphasise that knowledge is the capacity to act (Por and Molloy, 2000), which led to Alavi and Leidner (2001) publishing a variation of the aforementioned definition; they define knowledge as "justified personal belief that increases an individual's *capacity to take action*". O'Dell and Grayson (1998) also emphasise the 'capacity to act' by stating that knowledge is information in action. It is important to note, however, that knowledge is fundamental in interpreting and deriving meaning from information. Thus, whilst numerous individuals can be provided with the same information, it is likely all will interpret and use it differently based on their personal knowledge. Davenport and Prusak's (2000) definition of knowledge somewhat resonates with this perception by highlighting that knowledge is founded in and applied by people, but can also become embedded in artefacts:

> "Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms." (Davenport and Prusak, 2000)

However, the above describes the more prevalent cognitivist perspective, which is increasingly supplanted by socio-material constructivism (i.e. a system of fragmented knowledge whereby people jointly construct and reconstruct understanding of social and organisational action) (Bruni et al., 2007). A noteworthy difference between these two ontological schools is that cognitivism is concerned with how individuals apply cognitive structures to acquired knowledge to traverse particular situations, whereas socio-material constructivism is concerned with how individuals "use circumstances to accomplish intelligent actions" (Gherardi and Nicolini, 2000). This latter, more contemporary perspective, views knowledge as being emergent, fabricated and validated by situated activities that mobilise a bricolage of social, cultural, mental and material resources (Gherardi, 2003, Whyte et al., 2008).

McDermott (1999) proposes the following six characteristics to distinguish knowledge from information: knowing is a human act; knowledge is the residue of thinking; knowledge is created in the present moment; knowledge belongs to communities; knowledge circulates through communities in many ways; new knowledge is created at the boundaries of old.

At this point it is worth addressing the notion of wisdom. Wisdom, believed to supersede knowledge, is considered a highly creative and connective process of comprehending knowledge, enabling individuals to penetrate to the core of what really matters, both now and in the longer term (Allee, 1997). One might consider the capstone of this hierarchy to be enlightenment, which ultimately supersedes wisdom.

2.1.2 The Tacit-Explicit Distinction

A common distinction of knowledge is tacit and explicit. Originally proposed as a dichotomy by Michael Polanyi in the 1950's and popularised (again) by Nonaka and Takeuchi (1995), it's often believed to be the key to understanding whether or not a

knowledge management approach will be effective (Goh, 2002). A summary of tacit-explicit distinctions is provided in Table 2.1.

In essence, tacit knowledge (TK) is fundamental in mediating our day-to-day lives (Snowden, 1999), examples of which include: intuition, hunches, heuristics and inherent talent; "It is knowing how to ride a bike, how to recognise the smell of coffee, how to develop lasting client relationships, when to buy and sell, and which new venture is likely to work" (Callahan, 2005). However, it's rife with complexity; it's personal (paradigm-dependent), context-specific, abstract and dynamic. It is generally absorbed through (verbal and non-verbal) experience; people comprehend the complex relationships of systems with little or no awareness of doing so or the ability to articulate their understanding (Lubit, 2001). Thus, TK is often best understood by the assertion that "we know more than we can tell" (Polanyi, 1966); this can be exemplified as an iceberg where 10% is visible above water, whilst 90% is hidden away (Bhardwaj and Monin, 2006). This makes sharing TK difficult, with it often being considered 'sticky'; it requires more effort (time and energy) to mobilise (Christensen, 2007, Hansen et al., 2005, Hansen, 1999), and it's "not given to anyone in its totality" (Hayek, 1945). It is often believed that informal and interpersonal channels may be the best approach to alleviating 'stickiness' (Goh, 2002, Hislop, 2005, Daniel et al., 2003). Nonaka et al. (2000a) propose the concept of 'Ba'; a shared space/ context that enables relationships to emerge, serving as a foundation for knowledge creation. This allows individuals to embrace richer implicit non-verbal forms of communication; e.g. the transmission of sensations, feelings and values (Bhirud et al., 2005).

Table 2.1. Tacit-explicit knowledge distinctions

Tacit knowledge	Explicit knowledge
Know-how	Know-what
Subjective	Objective
Drawn from experience and it's the most powerful form of knowledge	Can become obsolete quickly
Difficult to articulate formally	Formal articulation possible and can be processed and stored by automatic means, or other media
Difficult to communicate and share	Easily communicated and shared
Includes privately held insights, feelings, culture and values	Formally articulated and public
Hard to steal or copy	Can be copied and imitated easily
Shared only when individuals are willing to engage in social interaction	Can be transmitted
Less-structured	Structured
'Soft'	'Hard'
Stored in human beings	Stored in artefacts

Adapted from: Daniel et al. (2003); Gupta (2008); Kimble and Hildreth (2005); Ward (2007)

Explicit knowledge (EK), by contrast, is unequivocal; it can be readily identified, articulated and codified (Nonaka et al., 2000b, Snowden, 1999). Whilst

TK is stored in human beings, EK is stored in artefacts (Gupta, 2008). Artefacts are artificial and exist in tangible physical (e.g. reports, drawings) or virtual (e.g. emails, databases) forms. Consequently, EK is easily transferred using formal systematic language and is reusable in a consistent and repeatable manner. This means EK lends itself to being measured (Harlow, 2008). So, in short, EK is information, albeit important information which helps individuals to create or develop their own TK (Clarke and Rollo, 2001, Joia, 2000).

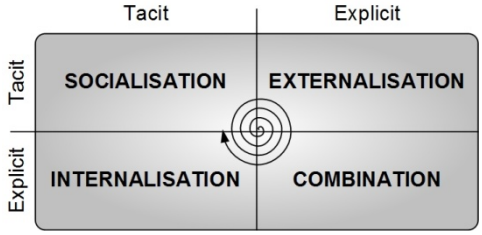
Whilst many authors consider the TK and EK distinction as a dichotomy (e.g. Von Krogh et al., 2000, Nonaka and Takeuchi, 1995), there is a strong argument that it's a duality (Kimble and Hildreth, 2005, Jasimuddin et al., 2005). This is primarily because "all knowledge is either tacit or rooted in tacit knowledge" (Polanyi, 1966). For example, EK could be interpreted differently by different individuals (Stevens et al., 2010). Consequently, from a dichotomised perspective EK is both meaningless and self-contradictory (Fernie et al., 2003). However, as explained earlier, TK can be created and developed through exposure to EK (Leonard-Barton and Sensiper, 1998). This is especially true of today's world where we are often entrenched in environments which are saturated with information. The author believes the Taoist philosophical concept of yin-yang (Figure 2.1) appropriately epitomises this perspective; TK and EK simultaneously and inextricably manifest themselves in each other, with their influences shifting according to context and maturity. Viewing knowledge in this way emphasises the importance of considering both TK and EK when attempting to manage knowledge (Kimble and Hildreth, 2005).

Another common argument is that TK and EK reside in a continuum, occupying the extremes at either end (Harlow, 2008). Whilst this concept embraces the ideals of strict TK and EK, it also emphasises that they are complementary. In the continuum a good many iterations exist between TK and EK: each iteration implies a level of codification (the degree to which TK is formally expressed) (Zander and Kogut, 1995). This view provides insight to the level of missing TK in order to manage, if necessary, the assimilation of the EK counterpart.

Figure 2.1. The yin-yang concept

2.1.3 Individual and Organisational Knowledge

The abovementioned knowledge perspectives are presented from an individual knowledge perspective, which is simply defined as the knowledge possessed by an individual. Organisational knowledge, on the other hand, is defined by Tsoukas and Vladimirou (2001) as "the capability members of an organization have developed to draw distinctions in the process of carrying out their work, in particular concrete contexts, by enacting sets of generalizations whose application depends on historically evolved collective understandings." This means that organisational knowledge is socially constructed (Jashapara, 2007). As such the organisation cannot create knowledge on its own; it requires the initiative of individuals and the interactions, consensus and agreement within groups and communities (Nonaka and Takeuchi, 1995, Jashapara, 2007).



Source: Nonaka et al. (2000a)

Figure 2.2. SECI: knowledge conversion process

Whilst numerous models exist for representing the creation of organisational knowledge (e.g. Bhatt, 2002, O'Dell and Grayson, 1998, Nonaka et al., 2000a, Gupta, 2008, Por and Molloy, 2000), the SECI (Socialisation, Externalisation, Combination, Internalisation) model is one of the most recognised (see Figure 2.2). It suggests that TK and EK go through alternating conversions, with both tacit, explicit, individual and organisational knowledge forms expanding in quality and quantity throughout the process (hence, the spiral analogy). Socialisation is the conversion of individual TK to organisational TK (Scott, 1998), which can only be achieved through shared experience; examples of this interaction would include apprenticeships and social meetings (Nonaka et al., 2000a). Externalisation occurs when TK is converted into EK, so that it can be stored and transmitted. Combination is the process of systematically linking and integrating the resultant externalisation knowledge with other organisational EK for dissemination amongst all organisational members. Technologies, such as databases and intranets, are often used to facilitate this process. Finally, internalisation is the embodiment of EK into TK, which is often exemplified by an iterative process of trial and error (Scott,

1998) for the knowledge to be actualised; i.e. 'learning by doing', experiments and simulations (Nonaka et al., 2000a). There are a number of factors that can inhibit this process, most of which are cultural (e.g. lack of trust, knowledge is power mentality, different frames of reference) or contextual (e.g. geographical locations, rules, technologies) (Bhatt, 2002, Scott, 1998).

2.2 KNOWLEDGE MANAGEMENT

As implied above, we are awash with knowledge – it governs everything we do. KM is subsequently concerned with developing and cultivating systems that enable organisations to detect, leverage, distribute and improve their knowledge assets (Nonaka, 2007), thus transforming them into strategic value. As such, KM initiatives are usually underpinned by strategic business goals, such as: increased innovation; reduced costs; greater market agility; better client and supplier relationships; and business continuity.

The following sub-sections briefly review KM's history, definitions, and components. It should be noted that the field of KM is vast and constantly growing, thus the literature reviewed here is limited for the purpose of this thesis.

2.2.1 History

As established in the preceding section, knowledge is not new. Consequently KM has always existed in one form or another as the human race has pursued knowledge, handing it down from generation to generation. 35,000 years ago, nomadic hunting tribes painted depictions of the creatures they encountered whilst traversing their environment; 5,000 years ago humans began recording events (e.g. the flooding of the Mesopotamia) and transactions (e.g. the handing over of The Laws to Hummurabi by Sumerian deity), representing knowledge transfer; in 300 BC Ptolemy I Soter commissioned the construction of the original Library of Alexandria, thus epitomising the first knowledge centre; and by the 13th century apprentice systems were based on pragmatic and systematic KM (Figallo and Rhine, 2002).

Despite KM practices existing for some time, KM only began to emerge as a discipline during the mid-1970's (Wiig, 1997), spurred on by pioneers such as Peter Drucker. It was during this time that organisations began to recognise the benefit of getting all organisational members to pull in the same direction; it was the decade of portfolio management, the experience curve and strategic planning. The term

'knowledge management' was coined in the 1980's by pioneer Karl-Erik Sveiby (cf. Sveiby and Lloyd, 1987). Around the same time Peter Senge defined 'learning organisations' based on 15 years of research at the Sloan School of Management at MIT (Call, 2005), which was the foundation of his renowned Fifth Discipline book publication (Senge et al., 1991). By the mid-1990's companies were beginning to recognise that the more successful companies were capitalising on their knowledge assets. According to Snowden (2002), it was around this time that the second age of KM was initiated through the popularisation of Nonaka and Takeuchi's (1995) SECI model (Figure 2.2) and the tacit-explicit knowledge concept. This meant increasing emphasis was placed on the competitiveness of human resources, with management being concerned with learning, unlearning and the value of experience (Gamble and Blackwell, 2001). Thus, it was at this point – the late-1990's – when the knowledge era commenced, with organisations attempting to manage their knowledge using new and systematic approaches. Whilst KM initiatives began by focusing individual knowledge codification, sharing and creation, there has more recently been a shift towards activities that chiefly attempt to manage KS and manage it as a collective activity (Huysman and de Wit, 2004).

Table 2.2. A selection of KM definitions

"…a process that helps organizations find, select, organize, disseminate, and transfer important information and expertise necessary for activities such as problem solving, dynamic learning, strategic planning and decision making." (Gupta et al., 2000)
"…the process through which organizations generate value from their intellectual and knowledge-based assets. Most often, generating value from such assets involves codifying what employees, partners and customers know, and sharing that information among employees, departments and even with other companies in an effort to devise best practices." (Levinson, 2007)
"The implementation of knowledge strategies comprises all person-orientated, organizational and technical instruments, suitable to dynamically optimise the organization-wide level of competencies, education and ability to learn of the members of the organization as well as to develop collective intelligence." (Maier, 2002)
"…it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings." (Malhotra, 1998)
"…a conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organizational performance." (O'Dell and Grayson, 1998)
"…the process of continually managing knowledge of all kinds to meet existing and emerging needs, to identify and exploit existing and acquired knowledge assets and to develop new opportunities." (Quintas et al., 1997)
"…the explicit and systematic management of vital knowledge and its associated processes of creating, gathering, organizing, diffusion, use and exploitation. It requires turning personal knowledge into corporate knowledge than can be widely shared throughout an organization and appropriately applied." (Skyrme, 2003)
"…identification, optimisation and active management of intellectual assets, either in the form of explicit knowledge held in artefacts or as tacit knowledge possessed by individuals or communities." (Snowden, 1998)
"…the dynamic process of turning an unreflective practice into a reflective one by elucidating the rules guiding the activities of the practice, by helping give a particular shape to collective understandings, and by facilitating the emergence of heuristic knowledge." (Tsoukas and Vladimirou, 2001)
"…the overall purpose of KM is to maximize the enterprise's knowledge-related effectiveness and returns from its knowledge assets and to renew them constantly." (Wiig, 1997)

2.2.2 Definitions

Due its vagueness, KM lends itself to multiple interpretations. A key reason for this lack of a clear unified definition is that KM is founded in a number of disciplines, predominately encompassing: philosophical studies (e.g. epistemology); management sciences; organisational sciences; economics; psychology; sociology; and computer science (Nonaka and Peltokorpi, 2006, Maier, 2002, Quintas et al., 1997, Prusak, 2001). Organisational KM definitions also vary because of their independent contexts (e.g. business strategy and markets) and their various cultures. Table 2.2 provides a selection of KM definitions (see Jennex (2005) for additional KM definitions).

It is generally agreed that, in one form or another, KM commonly comprises of the following 'steps': knowledge generation, knowledge sharing, knowledge adaptation, knowledge application, and knowledge modification (new knowledge generation) (Gupta, 2008).

2.3 KNOWLEDGE SHARING

In the twenty-first century KS is increasingly recognised as a key economic driver (Gupta, 2008). One reason for this is globalisation. The world is often said to be ‘a lot smaller these days’; the advent of cost-effective, efficient and seamless information and communication technologies (ICT) has meant that most of the developed world is connected to the internet. This technological step generated seismic changes in how businesses operate, in particular responding to high-tempo shifts in market conditions. Effective KS can help organisations become even more responsive to changing client needs and market trends (Smith and McKeen, 2007) by improving organisational performance through accelerated learning and innovation, thus delivering better products and services to markets and clients in shorter timeframes (Riege, 2005). Consequently, the challenge of enhancing organisational KS has become a key strategic concern (Yang and Chen, 2007, Taminiau et al., 2009), with organisations typically adopting approaches such as: communities of practice (Wenger et al., 2002); mentorship programmes, communication technologies (e.g. WebEx (CISCO, 2010)); skills and experience directories (Davenport and Prusak, 2000); face-to-face conferences; and so on. These KS activities have many benefits, including: greater organisational flexibility and agility; improved decision support; faster problem solving; reduced rework; and improved innovation, to name but a few.

The following sub-sections review what is actually meant by 'knowledge sharing', the components that often govern its effectiveness, and potential barriers to its success.

2.3.1 Definition

Unlike KM, perspectives on what KS entails are more consistent throughout the literature. Definitions of KS include: "a complex process involving the contribution of knowledge by the organisation or its people, and the collection, assimilation and application of knowledge by the organisation or its people" (Lichtenstein and Hunter, 2008); "the provision or receipt of task information, know-how and feedback regarding a product or procedure" (Cummings, 2004); and "a dual process of enquiring and contributing to knowledge through activities such as learning-by-observation, listening and asking, sharing ideas, giving advice, recognizing cues, and adopting patterns of behaviour" (Bosua and Scheepers, 2007). For the purposes of this thesis, KS is defined simply as "the social and dualistic activity of exchanging knowledge".

KS is often considered the most important facet of KM (Kalling and Styhre, 2003, Gupta, 2001, Schleimer and Riege, 2009). In fact, Alazmi and Zairi (2003) found it to be the most cited critical success factor for effective KM. It is the oldest and most practiced approach to generating new knowledge; in the absence of all explicit artefacts and communication tools (e.g. computers, pens and paper) we would still be able to share tacit knowledge, with or without managed processes (Davenport and Prusak, 2000). This means it is strongly associated with the socialisation phase of Nonaka and Takeuchi's (1995) SECI model (Figure 2.2) (Fernie et al., 2003, Handzic and Chaimungkalanont, 2004). Thus, the goal of KS is either to "create new knowledge by differently combining existing knowledge or to become better at exploiting existing knowledge" (Christensen, 2007).

2.3.2 Knowledge Sharing vs. Knowledge Transfer

It is noteworthy that KS is not the same as knowledge transfer (KT). The key difference is that KS is concerned with the tacit to tacit exchange of knowledge, whereas KT is concerned with the conversion of tacit to explicit knowledge (i.e. *externalisation*). These concepts are not mutually exclusive (Haas and Hansen, 2007), and are often used to enhance each other (e.g. the use of scrap paper to help share an idea). KS and KT are also closely related to the issue of exploration and

exploitation, respectively (Matsuo and Easterby-Smith, 2008). Exploration involves activities where new knowledge is created by sharing and synthesising knowledge, and is therefore associated with innovation and problem-solving. Exploitation, on the other hand, refers to the capture, integration and dissemination of existing knowledge (Bakker et al., 2006), thus refining and extending existing competencies, technologies and paradigms (March, 1991).

KS and KT are also affiliated with Davenport and Prusak's (2000) viscosity and velocity factors; i.e. the richness and speed at which knowledge is disseminated throughout an organisation (cf. Haas and Hansen, 2007). Often these factors are considered to reside at opposing ends of a spectrum; i.e. KS often exhibits high viscosity due to its interpersonal approach, but low velocity due to the time needed to identify and exchange knowledge (especially in large organisations), whereas KT often exhibits low viscosity due to tacit knowledge's inherent complexity and stickiness, but high velocity as it can quickly be disseminated through manual (e.g. postal mail, newspapers) and electronic (e.g. databases and networks) means.

2.3.3 Social Capital

Social capital (SC) is believed to be positively related to KS (Cohen and Prusak, 2001, Lesser and Storck, 2001) as it refers to the network of human relationships that connect people (Bresnen et al., 2005). It is evident that SC has resonances with socio-material constructivism as it is ultimately dependent on relationships between individuals for knowledge to emerge. Bresnen et al. (2005) asserts that this is especially important in project-based organisations which experience a fragmented and discontinuous way of working.

A widely cited definition of SC is provided by Nahapiet and Ghoshal (1998): "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit". They continue to assert that SC comprises of three interrelated dimensions: structural; relational and cognitive. The structural dimension refers to the pattern of relationships – who can be reached and how. The relational dimension describes the interpersonal relationship developed through interactions (Chow and Chan, 2008), and encompasses norms (behavioural expectations), obligations (sense of mutual reciprocity), trust and identification (sense of community) (Nahapiet and Ghoshal, 1998, Lesser and Storck, 2001); without these, individuals may hoard knowledge instead of sharing it (Vanasse and Poynton, 2003). Finally, the cognitive dimension

refers to the quality of the knowledge being exchanged (Kalling and Styhre, 2003), which is dependent on individuals sharing a common interest or language (i.e. meanings and understandings); this adheres community members whilst simultaneously excludes non-community individuals (Wenger et al., 2002).

The notion of social capital (SC) is a component of organisational capital, which is also comprised of physical capital, financial capital and human capital (Huysman and de Wit, 2004).

2.3.4 Organisational Culture

Culture is a highly complex, dynamic phenomenon that governs the way we interface with the world around us, either as individuals or as groups (e.g. communities, teams or organisations). It is the character or personality of an organisation, which is often described as 'the way things are done in an organisation' (Park et al., 2004). Whilst there are many precise definitions of organisational culture (cf. Palanisamy, 2007), the following definition shall be adopted for this thesis:

> "…the pattern of shared values of the group lead people in the group to think and act similarly, and it is a system of perceptions, meanings, values and beliefs which facilitates individuals and groups to share the common experiences. It emerges from the social interaction of organizational members and is the product of shared symbols and meanings." (Palanisamy, 2007)

It widely recognised that organisational culture directly affects KS capability and approaches (Tiwana, 1999). In fact, it is the most frequently cited supporting factor for KS (McDermott and O'Dell, 2001, Small and Sage, 2006, Yang and Chen, 2007). De Long and Fahey (2000) recognised the need to overcome this increasingly recognised barrier to effective KM; in a bid to provide greater insight to this complex phenomenon they identified four ways in which organisational culture influences KM behaviour:

- culture-and particularly subcultures-shape our assumptions about what knowledge is, and, hence, which knowledge is worth managing;
- culture mediates relationships between individual and organizational knowledge;

- culture creates the context for social interaction that ultimately determines how effective an organization can be at creating, sharing, and applying knowledge; and
- culture shapes the processes by which new organizational knowledge-with its accompanying uncertainties-is created, legitimated, and distributed.

Gupta and Govindarajan (2000) suggest that organisational culture consists of six major categories: people (i.e. trust, motivation and interaction); process; reward systems; leadership; organisational structure, and information systems (cf. Al-Alawi et al., 2007). This framework is adopted to address the key factors that affect KS performance, which are presented in the following sub-sections.

2.3.5 People

Trust

A high level of mutual trust between individuals and groups is a prerequisite for effective KS (Goh, 2002); "Without trust, knowledge initiatives will fail" (Davenport and Prusak, 2000). In principal, trust is "the willingness of one party to be vulnerable to the actions of another party, and it is a function of access to information either through direct or indirect interactions" (Lucas, 2005). An environment that exhibits trust should contribute to effective KS (Szulanski, 1996), making exchanges less costly and increasing the likelihood that the exchanged knowledge is sufficiently understood and absorbed for its future application (Mooradian et al., 2006, Lucas, 2005). On the other hand, an atmosphere which exhibits little or no trust can make knowledge exchanges more difficult and the knowledge itself is likely to be challenged or resisted (Inkpen and Tsang, 2005). Furthermore, Bakker et al. (2006) found that trust is a condition of KS; i.e. it is a prerequisite for knowledge exchange, but does not have a positive effect on it per se, "although the absence of trust may impede people's motivation to share knowledge with others, it is unlikely that those who have high levels of trust in others are more likely to share knowledge than those with moderate trust levels."

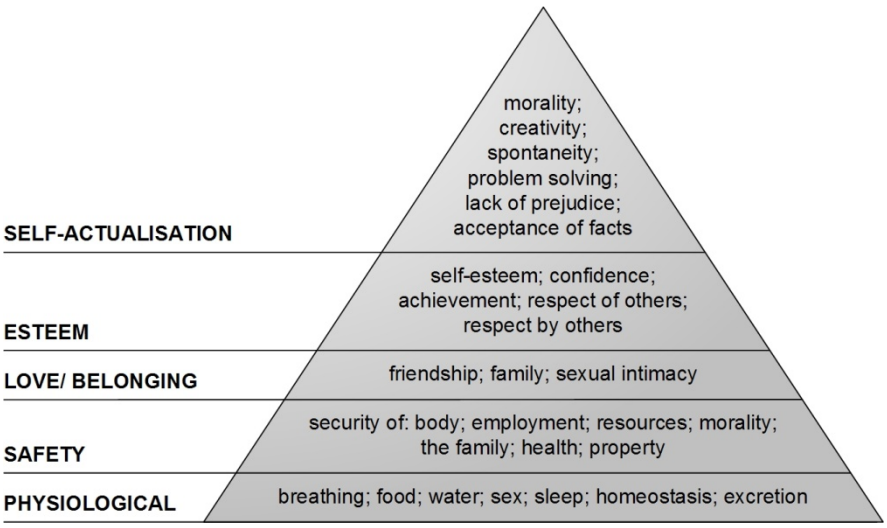
Trust is developed through experience and therefore accumulates over time (Koskinen et al., 2003); it cannot be forced, but can be nurtured through positive interaction (Chan and Liebowitz, 2006). The rate of which trust develops is often contingent upon the knowledge being exchanged (Wang et al., 2006); for example, the value or richness of the exchange. However, the author also believes that whilst trust is built up over long periods of time, it can quickly diminish should a

knowledge exchange result in an unexpected outcome (e.g. the exchange of erroneous knowledge). According to Abrams et al. (2003), in the context of KS trust is made up of two component parts; benevolence (the disposition to do good) and competence (being adequately qualified). Benevolence-based trust allows individuals to seek knowledge from another without fearing damage to their self-esteem or reputation. Competence-based trust allows an individual to feel confident that the exchanged knowledge is credible; for example, the knowledge 'sender' has a good reputation (Lucas, 2005).

Motivation

Motivation refers to the desire or willingness to do something that benefits the self or an immediate group (OED, 2011, Burgess, 2005). Cultivating an organisational culture where KS is embraced as the norm is impossible unless its members are willing to participate (Mei et al., 2004). As such, understanding what motivates individuals to share knowledge is a key challenge for organisations (Milne, 2007), whilst effective motivation is very difficult to accomplish (Bishop et al., 2008). Interestingly, in a study of ten large companies, Huysman and de Wit (2004) observed that "people often do feel the need to learn and share knowledge with others in situations where this would help them work better, more efficiently and with more satisfaction", thus implying that major organisational reform is not a prerequisite for motivating individuals to volunteer and share their knowledge.

Maslow's hierarchy of needs and Herzberg's two-factor are probably the best known motivation theories (Hendriks, 1999). The basis for Maslow's (1954) theory is that human beings are motivated by unsatisfied needs. Figure 2.3 presents the classifications and primary needs; individuals must satisfy the lower needs before progressing up the pyramid towards self-actualisation. It is important to note, however, that the more fundamental (lower down the pyramid) the need is, the more likely an individual will abandon higher needs in order to satisfy lower needs. Herzberg's (1974) theory, on the other hand, suggests that individuals are influenced by two factors: motivation (e.g. achivement, recognition for achivement, responsbility) and hygenie (e.g. salary, job security, interpersonal relationships). Whilst hygenie factors aim to avoid unpleasantness in organisational settings and are more related to extrinsic reward systems, motivational factors encompass individuals' intrinsic need for personal growth.



Source: Maslow (1954)

Figure 2.3. Maslow's hierarchy of needs

Matsuo and Easterby-Smith (2008) suggest that motivational factors vary depending on the quality of an interpersonal relationship, implying a connection with interpersonal trust. Lin (2007) identified two motivational factors related to KS; the enjoyment of helping others and self-efficacy were found to positively influence motivation. Conversely, Szulanski (1996) provides a set of causes for poor motivation: a fear of losing ownership, a position of privilege, or superiority; resentment for a lack of an adequate reward system; or an unwillingness to devote time and resources to support the knowledge exchange. Szulanski (1996) continues by suggesting that these causes may exhibit the following symptoms: foot dragging, passivity, feigned acceptance, hidden sabotage, or outright rejection in the implementation and use of new knowledge.

Interaction

Interaction refers to face-to-face communication, which is underpinned by social networks (SNs) (Al-Alawi et al., 2007). Face-to-face interaction is believed to be the richest medium for exchanging knowledge as it allows immediate feedback, thus understanding can be confirmed and interpretations corrected (Koskinen et al., 2003).

SNs are a long-term benefit of positive social capital (Huysman and de Wit, 2004, Otto and Simon, 2008), which play an important role in accessing knowledge (Christensen, 2007). Organisational social networks ideally connect a collection of individuals, directly or indirectly, across functional, geographic or organisational boundaries (Smith and McKeen, 2007) via a series of established relationships

(Zack, 2002). Studies have shown that SNs are often crucial for effective KM (Fliaster and Spiess, 2008, cf. Dyer and Nobeoka, 2000). In fact, many studies have shown that scientists and engineers are roughly five times more likely to seek knowledge and information from friends or colleagues, in comparison to more impersonal sources such as intranet systems (Cross et al., 2002b, Handy, 1994).

SNs have two overarching goals; to facilitate *knowledge search* and *knowledge transfer* (Smith and McKeen, 2007). Knowledge search often comprises of a group of individuals who need knowledge for a particular situation. It is initiated by using existing knowledge to determine which contact may be most effective in identifying the sought knowledge; this is navigated by the structural and relational dimensions of SC. Organisational knowledge searching can be intra-team (e.g. within business units or project teams) or inter-team (e.g. seeking across functional boundaries) (Hansen et al., 2005). If the knowledge search is successful in identifying useful knowledge, it then needs to be transferred from the source to the recipient through a knowledge exchange activity. At this point, SC's relational and cognitive dimensions are positively related to the effectiveness of the transfer, in addition to each party's personal ability (i.e. absorptive capacity (Tsai, 2001)). Research shows that a lack of knowledge sharing experience can lead to difficulties in the transfer process (Cummings, 2003). However, should a knowledge transfer be successful, substantial cost savings and strategic value may be achieved (Smith and McKeen, 2007) with further intangible benefits emanating from the experience; such as enhanced knowledge sharing behaviour and greater knowledge awareness (Cummings, 2003).

2.3.6 Processes

At its fundamental level, KS comprises of processes through which knowledge is exchanged (Cummings, 2003). Managing these processes is a daunting task, as social interaction stimulates KS, processes have limited direct influence (van den Hooff and Huysman, 2009). Furthermore, for KS processes to be successful it is important that they are interlinked and harmonised with other aspects of the organisation's KS culture and other business processes (e.g. the reward system) (Gupta, 2008).

KS processes fall into one of two categories: formal and informal. Formal processes comprise of resources, services and activities that are designed and institutionalised by management (Taminiau et al., 2009). Formal exchange

mechanisms include: regular project meetings; organised mind-mapping sessions; and some educational programmes. Informal processes, on the other hand, generally refer to informal and impromptu knowledge exchanges (cf. Brown and Gray, 1995). Whilst management have very little control over informal exchanges, they can cultivate such behaviour by providing contexts which enhance organisational members' trust, motivation and interaction. Two dominant characteristics of such enabling contexts are organisational time and space (Riege, 2005, cf. Wakefield, 2008); e.g. Nonaka and Konno's (1998) originating '*Ba*'. However, neither category by itself is perfect; Taminiau et al. (2009) found that KS often involves alternating between formal and informal processes, suggesting that both categories are required for effective KS.

2.3.7 Reward Systems

It has been found that people often enjoy activities or tasks more when they receive a reward (Milne, 2007). This resonates with the notion that people are more likely to share knowledge if they receive something in return (Payne and Sheehan, 2004). Whilst the abovementioned motivation category focuses on intrinsic rewards (Burgess, 2005), reward systems are based on extrinsic rewards. In other words, reward systems can provide appropriate mechanisms to encourage KS for organisational goals (Goh, 2002, Choi et al., 2008).

A key benefit of extrinsic rewards is that they explicitly encourage activities that the organisation deems important (Burgess, 2005); e.g. horizontal communication (Davenport and Prusak, 2000). Rewards can be either tangible, which are often fiscal (e.g. bonuses, prizes, promotion), or intangible recognition (e.g. acknowledging an individual's exceptional behaviour). Studies have shown that despite many organisations utilising tangible reward systems, such systems only provide temporary KS incentives (cf. Lin, 2007). Recognition, however, is often non-financial and perceived as being more suitable for encouraging strategic KS behaviour (Bishop et al., 2008).

2.3.8 Leadership

Leaders play an important role in navigating an organisational culture toward the conditions required for KS (Lakshman, 2007, Goh, 2002) (e.g. enhancing group KS by focusing on building interpersonal trust (Lee et al., 2010)). Facilitator and mentor leadership roles have been "significantly and positively related" to KS

performance (Yang, 2007), whilst both of these roles aim to foster interpersonal relationships, facilitators emphasise group harmony and consensus, attempt to minimise conflict, and encourage participation in organisational activities (e.g. problem solving), whereas mentors assist subordinates in developing competencies (e.g. a formal arrangement such as an apprenticeship, or an informal arrangement such as providing advice and support (Payne and Sheehan, 2004)).

Senior management support is also required to encourage KS (Dasgupta and Gupta, 2009); should this support be lacking it is likely any efforts will fizzle and fail (O'Dell and Grayson, 1998, Singh, 2008). Lin (Lin, 2007) found that senior management support improved organisational members' willingness to donate and seek knowledge; surpassing the benefits associated with extrinsic reward systems. According to Mei et al. (2004) this willingness can be enhanced through the following actions:

- establishing individual and team performance goals aligned with the intended changes;
- measuring people against the goals;
- establishing effective two-way coaching and feedback mechanisms; and
- rewarding and recognizing people for achieving the goals and implementing the changes.

Many organisations have created dedicated CKO roles who are responsible for driving success (Bishop et al., 2008); i.e. building a knowledge culture, creating a KM infrastructure, and ensuring that knowledge is converted into profit (Davenport and Prusak, 2000). Bontis (2001) highlights the multi-disciplinary nature required by a CKO, suggesting the role is primarily based on juggling the following five roles: CKO as knowledge-sharing icon; CKO as trust steward; CKO as total trainer; CKO as techno nerd; and CKO as number-crunching accountant.

2.3.9 Organisational Structure

An organisational structure should encourage members to share their knowledge (Bhirud et al., 2005). Traditional formal hierarchical structures are a common way of coordinating a complex system comprising of numerous specialised units and reporting procedures (Tsai, 2002, Al-Alawi et al., 2007). However, it has long been understood that such formal structures do not reflect how work actually gets done in organisations (Chan and Liebowitz, 2006, Galbraith, 1973). It is also increasingly

recognised that such rigid, bureaucratic structures hamper intra-organisational KS (Tsai, 2002) and are no longer suitable in modern competitive environments (Von Krogh et al., 2000). Consequently, organisational designs that encourage greater lateral interaction and communication are increasingly sought (Goh, 2002).

Decentralised, informal organisational forms have attracted much attention from senior management in recent years (Chan and Liebowitz, 2006), as they allow greater flexibility in shifting market needs, whilst challenging and stretching the capabilities of its members (Kini, 2000, Egbu and Robinson, 2005). Manifested in informal relationships, organisations that adopt these forms are also likely to exhibit significant KS improvements (e.g. greater inter-unit sharing and innovation) (Tsai, 2002). However, most organisations are still wary of approaches that focus on social networks as they consider them to unobservable and ungovernable (Cross and Prusak, 2002).

2.3.10 Information Systems

The use of information systems for KS is regularly contested throughout the literature. The principal debate is whether they enhance or negate KS effectiveness (cf. Choi et al., 2008). However, there is consensus regarding the fact that many people interface with information systems on a daily basis (Bosua and Scheepers, 2007), and that organisations are investing heavily in increasingly sophisticated information systems (cf. Abrams et al., 2003).

It should be noted that KS information systems are not concerned with the codification of knowledge per se; that would diverge from its emphasis on the socialisation of tacit knowledge. Therefore it is noteworthy that KS can be highly effective without information systems (Dave and Koskela, 2009, Mohamed et al., 2010). In fact, many KM projects that have focused solely on information systems did meet client expectations (Handzic and Chaimungkalanont, 2004). A likely reason for this is that dedicated KS information systems do not drive KS behaviour; they support it (Coakes, 2006). In other words, information systems can raise awareness of and provide access to knowledgeable sources, but this is not the same as exchanging knowledge. Furthermore, consideration of the effects on other KS cultural categories is necessary when employing KS information systems, especially motivation, trust and shared understanding (van den Hooff and Huysman, 2009, Van Baalen et al., 2005).

Nonetheless, there is a strong argument for implementing KS information systems (cf. Bosua and Scheepers, 2007), especially in large international organisations. Providing that KS information systems account for the socio-organisational aspects that underpin KM (Rezgui et al., 2010) (e.g. lateral interaction and communication) and are transparent and useable in locating knowledgeable sources (Payne and Sheehan, 2004, cf. Hew and Hara, 2007), they can prove especially useful in lowering temporal and spatial KS barriers (Coakes, 2006, Hendriks, 1999, Choi et al., 2008), enabling distributed individuals to work in creative and innovative ways. Typical KS information systems are inventory systems that signpost what types of knowledge exist (e.g. competencies, experience), where it exists (e.g. person, desk location), and exchange possibilities (e.g. telephone number, email address, community memberships) (Lucas, 2005); such systems include person finders, skills directories, event diaries, and intranets.

2.3.11 Barriers to Effective Knowledge Sharing

Whilst an organisational culture that embraces KS as the norm can achieve remarkable things, it's inherent complex, dynamic nature can make cultivating it a very challenging affair. Consequently, there are numerous barriers to and symptoms of a lack of harmony amongst the abovementioned six organisational culture categories, which can impede effective KS. Riege (2005) found that KS initiatives generally fail because organisations attempt to change their culture rather than designing initiatives that fit the existing culture. However, this perspective is not always shared; many authors refer to the creation and maintenance of KS cultures (e.g. van den Hooff and Huysman, 2009, Cummings, 2003).

Through compiling a holistic set of potential KS barriers, Riege (2005) found that KS barriers could be categorised into one of three domains: individual/ personal; organisational; and technological. Individual barriers include: lack of time to share; lack of trust; demographic differences; poor communication skills; weak social networks; and so on. Organisational barriers include: missing or poorly aligned KM strategy with overall organisational strategy; poor formal and informal environments; bureaucratic structures; high inter-unit competition; and so on. Technological barriers include: unwillingness to use information systems due to lack of familiarity and experience; misalignment between users' requirements and service; unrealistic expectations of what systems can or cannot do; and so on. These barriers, amongst others, are widely recognised and discussed throughout the

literature; for example, Riege (2005), Gupta (2008), Bhirud et al. (2005), Davenport and Prusak (2000), and Sveiby (2007), to name but a few.

2.4 SUSTAINABLE DEVELOPMENT

The need for sustainable development was recognised in antiquity; for example, Plato (1967) deplored the deforestation and farming in Attica for its negative impacts. Sadly for society, only in the past three decades has it been increasingly realised that the existing model for development is unsustainable (Hansmann, 2010, cf. Creech, 2009). Issues such as population growth, climate change, decline in biodiversity, poverty, food production, and water scarcity reinforce the need for changes in how the human race interfaces with their environment. This realisation, predominately propagated by the media (cf. Barkemeyer et al., 2009), has generated a sense of urgency to adopt sustainable principles (cf. Glavič and Lukman, 2007) as the deterioration of our life-support systems worsens (Goodland and Daly, 1996). In response, a growing body of research aims to deal with SD issues and its inherent complexities. This has resulted in the rapid evolution of philosophies and practices, with new ideas and innovation quickly becoming outdated (Newman and Dale, 2005).

The following sub-sections consider the complex nature of SD by reviewing various definitions and models, and how KS could enhance SD performance.

2.4.1 Definitions

It has been more than two decades since Gro Brundtland's (1987) WCED report popularised SD, defining it as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs". Since then various other definitions have surfaced, each attempting to encapsulate the true nature of SD. For example, Andrew Sage (1999) recognises it as an approach to "the fulfilment of human needs through simultaneous socioeconomic and technological progress and conservation of the earth's natural systems", whereas Forum for the Future, a leading non-profit UK based organisation with a mission to promote SD, define SD as "a dynamic process which enables all people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the Earth's life support systems" (FftF, 2010). Whilst these and other definitions of SD are broad and open to interpretation, they

share a key feature; they all emphasise human well-being and how to sustain that well-being over time (Atkinson, 2008).

Despite a myriad of definitions and perspectives, such as those mentioned above, confusion still surrounds SD and what it means in practice (Aras and Crowther, 2009, Brown et al., 1987, cf. Chaharbaghi and Willis, 1999). Whilst this 'fuzziness' can be frustrating for researchers and practitioners alike, generating a manifold of complex considerations, some advocate that by not confining SD to one definition avoids excluding perspectives on what SD should entail (Robinson, 2004). For example, Brundtland (1987) consciously embedded ambiguity into her definition in order to popularise it throughout a diverse constituency (Chaharbaghi and Willis, 1999). However, others also argue that a lack of agreement on what SD means and entails is a major barrier to implementation (Seiffert and Loch, 2005). Some authors believe this barrier to be founded in the oxymoronic term 'sustainable development'; in other words, our planet is finite in nature and thus continuous growth is simply unachievable (Daly, 1990), as is simultaneously sustaining and developing something (Seiffert and Loch, 2005).

2.4.2 Sustainable Development vs. Sustainability

Although the terms 'sustainable development' and 'sustainability' are loosely coupled (Aras and Crowther, 2009), it is important to recognise that they have different connotations; "sustainable development can be seen as a journey towards a destination: 'sustainability'" (Lutzkendorf and Lorenz, 2005), whereas sustainability is "the focus on the long-term survival of humanity" (Boyle and Coates, 2005). Interestingly, in a study of 115 leading newspapers worldwide, Barkemeyer et al. (2009) found that 'sustainable development' was the most widespread term until the mid-1990's, when 'sustainability' became the more commonly used term. Furthermore, their research suggested that should one purchase a leading newspaper from anywhere in the world, it would have a 50% chance of containing the term 'sustainable development' or 'sustainability' in one language or the other.

2.4.3 Risk and Uncertainty

There is growing recognition that SD issues are inherently complex and fuzzy (Curran, 2009, Godfrey, 2006). As such, the consequences of SD activity is neither immediate nor unambiguous (Senge et al., 1991), representing scientific and technological risk and uncertainty. Sage (1999) states that this doesn't simply refer

to the existence of risks and uncertainties, but also knowledge and information imperfections. To overcome these issues, Boyle and Coates (2005) advocate the adoption of systems thinking and process thinking approaches to account for complex interactions and change over time (Badiru, 2010, cf. Seiffert and Loch, 2005). Approaches, such as these, can reduce risk and uncertainty, accelerating the rate and degree of SD activity (Stern, 2006).

2.4.4 Knowledge Sharing

Knowledge is considered the critical foundation for SD (Mohamed et al., 2009). As such KS can help organisations realise the goals of sustainable development (Hansmann, 2010, Sage, 1999). This is supported by research that advocates the need for greater SD sharing across organisational and geographic boundaries to catalyse the evolution of individual and organisational SD knowledge (Rydin et al., 2007, Cash et al., 2003), enabling knowledge gaps to be closed (cf. Meer et al., 2009).

A substantial volume of SD KM research exists, generally focusing on knowledge transfer and innovative information systems (Dave and Koskela, 2009). However, relatively little published work is concerned with the social aspects of sharing SD knowledge in a civil engineering context (Newell et al., 2006, Meer et al., 2009). The author believes that KS's interpersonal tacit-to-tacit approach is adept in dealing with the complex, dynamic nature of SD knowledge (Chaharbaghi and Willis, 1999); KT may become cumbersome when attempting to re-codifying and re-assimilating variants of rapidly evolving SD knowledge (Gluch and Raisanen, 2009).

2.5 CIVIL ENGINEERING

Civil engineering is one of the oldest engineering disciplines. The UK's Institution of Civil Engineers (ICE) defines civil engineering as: "creating, improving and protecting the environment in which we live. It provides the facilities for day-to-day life and for transport and industry to go about its work. … [It is a] discipline that deals with the design, construction and maintenance of the physical and naturally built environment" (ICE, 2010). As such, civil engineering is comprised of a broad range of sub-disciplines (e.g. structural engineering, geotechnical engineering, rail engineering, water engineering, and so on), which are often required to interface in order to deliver projects.

The economic contributions of the civil engineering related disciplines is considerable (UNEP, 2003). Its market is worth roughly $4.7 trillion, constituting as much as 10% global GDP (WGBC, 2010), whilst it directly employs between 5-10% of the workforce in most countries (UNEP, 2007). However, despite these impressive figures, it is a competitive market which exhibits low profit margins (Carrillo and Chinowsky, 2006). Consequently, intangible assets are increasingly recognised as a differentiating competitive factor (Riege, 2005, Ruikar et al., 2007).

Civil engineering projects are complex, interdisciplinary, temporary in nature and generally involve "large, expensive, unique, and high risk undertakings which have to be completed by a certain date, for a certain amount of money, within some expected level of performance" (Koskinen et al., 2003). However, project environments can create organisational fragmentation (Kasvi et al., 2003), a problem which is regularly recognised throughout the civil engineering related disciplines (Dave and Koskela, 2009). Consequently, concern has been expressed regarding the traditional nature of the sector; it is expected to modernise and adopt sustainable approaches and collaborative (Myers, 2005).

The following sub-sections address the concepts of sustainable development and knowledge sharing in the context of civil engineering.

2.5.1 Sustainable Development

Civil engineering projects can have wide ranging and long lasting effects on our environment; their outputs alter the nature, function and appearance of urban and rural areas in which people live and work (Shelbourn et al., 2006). Therefore, they play a major role in SD, whilst also directly and indirectly affecting SD efforts in other industries. Unfortunately, it is widely understood that civil engineering related disciplines have been slow to embrace environmentally-friendly practices (Myers, 2005, Ofori, 1998). This is a likely result of the sector's complex and fragmented nature, creating a tendency to resist change (Boddy et al., 2007).

Whilst some civil engineering communities were campaigning for environmentally conscientious practice (cf. Lutzkendorf and Lorenz, 2005), during the past few years there has been a significant shifts towards holistic SD practice (Curran, 2009). This emerging approach is often referred to as 'sustainable construction', which aims to incorporate SD principles into conventional civil engineering approaches (Presley and Meade, 2010). Other common terms that refer

to SD in a civil engineering context include: ‘sustainable building’; ‘green building’; and ‘green construction’. The transition to sustainable construction potentially emanated from concerns about public and client perception, the anticipation of future regulation (Seiffert and Loch, 2005), and the recognition that there are “strong business benefits for sustainable construction” (Shelbourn et al., 2006).

Regulation is an important driver of SD; it ensures that all components (e.g. economic, environmental, social) are considered in relation to each other and that such considerations are institutionalised (O'Connor, 2006). Moreover, if correctly designed, regulation can trigger innovation, leading to reduced costs and higher value outputs (Chaharbaghi and Willis, 1999). Consequently, there have been many initiatives that have encouraged the reform in the civil engineering sector. For example, the International Organization for Standardization (ISO) has released numerous SD related standards, including: ISO 14001 (environmental management systems); ISO 21930 (sustainability in building construction – environmental declaration of building products); ISO 15392 (sustainability in building construction – general principles); and ISO 26000 (social responsibility). Furthermore, the UK government have devised a strategy for more sustainable construction (DETR, 2000); its aim was to drive change whilst negating the detrimental impacts associated with civil engineering related disciplines. Key factors for action included: design for minimum waste; lean construction; minimise energy in construction and use; do not pollute; preserve and enhance biodiversity; conserve water resources; respect people and local environment; and setting targets, monitoring and reporting, in order to benchmark performance (Addis and Talbot, 2001, Cole, 2000, Ofori et al., 2000, Presley and Meade, 2010).

2.5.2 Knowledge Sharing

Civil engineering organisations are learning organisations (Esmi and Ennals, 2009), and therefore operate in the knowledge economy (Egbu and Robinson, 2005, Shelbourn et al., 2006). Consequently, there is growing recognition of the potential benefits of KM (cf. Anumba et al., 2005), especially in large geographically-dispersed civil engineering organisations (Carrillo and Chinowsky, 2006). Nonetheless, KM is still immature in most civil engineering organisations, despite their interest and efforts (Esmi and Ennals, 2009). One such example of this is their conservative approach to adopting technical KM systems, whilst other industry sectors have been successfully embracing and capitalising on such systems (Dave and Koskela, 2009, Ruikar et al., 2007). The following ranked list of KM

implementation barriers identified by Carrillo et al. (2004) sheds light on the reasons for poor KM in civil engineering organisations: (i) lack of standard work processes; (ii) not enough time; (iii) organisational culture; (iv) not enough money; (v) employee resistance; and (vi) poor IT infrastructure. Whilst these barriers are recognised in other industry sectors (cf. 2.3.11: *Barriers to Effective Knowledge Sharing*), in one form or another they have been repeatedly identified in civil engineering contexts (e.g. Esmi and Ennals, 2009, Payne and Sheehan, 2004, Fong, 2005).

Although the need for KM is apparent many organisations fail to achieve the benefits of KS (Esmi and Ennals, 2009), which is often considered the key driver of civil engineering KM initiatives (cf. Carrillo et al., 2004). Shelbourn et al. (2006) propose that this may be due to a lack of mechanisms and processes that foster socialisation, despite the fact that effective communication is vital for successful civil engineering teams and projects (Gluch and Raisanen, 2009). In addition, the exchange of tacit knowledge advocated by KS approaches is recognised for overcoming the complex, fragmented and project-led characteristics associated with civil engineering related organisations (Dave and Koskela, 2009, Bresnen et al., 2005).

2.6 SYSTEMATIC LITERATURE REVIEW

In response to the lack of existing KS for SD research in civil engineering, the author conducted a systematic literature review to identify primary data studies that focused on KS for SD in civil engineering contexts. The study aimed to understand which KS concepts had been applied, the research strategies used, and the key findings from the research. Unlike traditional literature reviews, systematic reviews aim to minimise bias by providing an audit trail of reviewers' decisions, procedures and conclusions (Cook et al., 1997, Petticrew and Roberts, 2005). This increases methodological rigour and helps to develop a reliable knowledge base from a range of sources (Tranfield et al., 2003).

Using Tranfield et al.'s (2003) *stages of a systematic review* and an exclusion criterion, twenty studies were identified. Sections 3.4.1 and 4.1.2 discuss how this research activity plugs into the research design. Furthermore, this research activity is currently under second review with a peer-reviewed journal, a copy of which is located in Appendix A, which presents the study in its entirety.

The following eight KS concepts directly emanated from the studies: collaboration; decision support; education; measurement; social learning; social networks; public participation; and technology transfer. Collaboration featured in one form or another in almost all of the studies. It was also the most commonly studied concept, emphasising the need for an integrated approach to SD. Furthermore, the majority of these studies were concerned with the socialisation of members with differing backgrounds. Such diverse knowledge exchanges are believed to enhance problem solving and knowledge creation (Fong, 2005). To some extent, all of the collaboration studies investigated the application of formal processes to encourage KS behaviours; mixed results were obtained, with some not meeting expectations (cf. Lyver, 2005). However, informal interpersonal collaborative agreements were also found to often fall short of expectations (cf. Margerum, 2001).

UNCED (1993) stated that "Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues." Educational programmes that emphasised the exchange of knowledge were the second most common KS concept. The studies focused on: understanding SD educational requirements (cf. Morgenroth et al., 2004); providing platforms to build shared understanding amongst those already knowledgeable in SD topics (cf. Huisingh and Mebratu, 2000, Sage, 2000); educating individuals and organisations to realise the need for SD (cf. Gao et al., 2006); and vocational educational programmes for SD related design (cf. Pohl et al., 2009). Social learning studies resonate with the educational programmes but are more informal, allowing participants to explore and evolve a shared understanding (Wenger, 2000). These studies reported positive outcomes, enabling communities of individuals to socialise their knowledge within the scope of a shared goal. It was also recognised that a combination formal and informal mechanisms were evident in both the educational programmes and social learning studies.

Whilst numerous studies reported the emergence and development of social networks, only one attempted to analyse members' interaction (cf. Lauber et al., 2008). This is somewhat surprising considering the fragmented nature of the civil engineering sector and the integrated requirements of SD. Approaches, such as social network analysis, enable organisations to analyse their social capital, allowing them to identify opportunities for improvement (Liebowitz, 2005, Chan and Liebowitz, 2006). Nevertheless, it was also recognised that the studies

predominately focused on inter-organisational KS, despite the need for intra-organisational KS to precede inter-organisational KS (Mohamed et al., 2009).

Finally, the majority of the studies were either surveys (45%) or case studies (35%). Such positivistic research strategies can limit the understanding of complex perspectives and interactions, which are inherent in KS and SD. This is reinforced by the fact that all 20 studies made reference, to some extent, to the importance of organisational culture in directly influencing KS effectiveness. This resonated with the research reported in Section 2.3, with the *people* category (Section 2.3.5) receiving most attention; the studies repeatedly emphasised the need for regular interaction and trust.

2.7 DISCUSSION AND CONCLUSION

This chapter has provided an overview of the main topics addressed in this thesis; i.e. knowledge sharing, sustainable development and civil engineering, and the relationship between these topics. The reviewed literature, although limited, is summarised in this section with the aim of highlighting gaps and the need for the reported research.

The discussed literature advocates that SD is necessary to alleviate the increasing stress placed on the planet's finite resources and delicate ecosystem, whilst recognising the purpose of and need for other non-natural factors (e.g. economic). However, achieving the status of sustainability is no easy feat; SD is rife with complexity, generating an array of perceptions, considerations, interdisciplinary approaches, risks and uncertainties. Nonetheless, it is crucial that these challenges do not prevent SD practice; it would most likely prove more detrimental to do nothing at all (i.e. continue in an unsustainable fashion).

The literature also suggests that civil engineering related disciplines exhibit traditional characteristics, with it being urged to adopt more sustainable and collaborative approaches. From a SD point of view, its performance has been lagging behind other industry sectors. Reasons for this seem to stem from the sector's size and atypical client needs, which have created complex, fragmented organisational environments that often resist change. However, civil engineering organisations are increasingly aware of their significant impact and influence with respect to the environment and the way we interface with our habitats. This increased awareness – which is predominately derived from media attention,

regulatory drivers and market differentiation tactics – is generating increasing SD practice.

KS was found to be an integral aspect of knowledge management, positively related to social capital and heavily governed by the following organisational culture categories: people; processes; reward systems; leadership; organisational structure; and information systems. For the purposes of this thesis KS was defined as "the social and dualistic activity of exchanging knowledge", emphasising the tacit-to-tacit nature of the process. Enhancing organisational KS is on many organisations' strategic agenda as it can accelerate learning and innovation, thus enhancing organisational performance and agility. However, numerous barriers to effective KS were also identified.

There are some similarities between SD and civil engineering; they exhibit high-levels of complexity, require interdisciplinary approaches, and are heavily dependent on knowledge. The reviewed literature implied that KS could alleviate the challenges associated with these similarities. As such, KS could support civil engineering related organisations in attaining the goals of SD by building shared understanding, lowering cross-boundary barriers, and supporting problem solving and innovation, for example. However, it was also recognised that, despite generally focusing on KS activities, civil engineering related disciplines often fail to achieve effective KS, with six core barriers being identified; we shall return to these later in the thesis.

A systematic literature review was conducted to determine which KS approaches had been employed to improve SD in a civil engineering oriented context, along with their research strategies and key findings. This identified a small number of studies, most which were conducted using surveys or case studies. Collaboration and education were the most common studied KS themes, with social networks often playing a crucial 'behind the scenes' KS role. Furthermore, most studies did not consider intra-organisational KS for SD, which is considered to be an important knowledge gap.

This research activity has revealed an important gap in the extant literature reviewed here. KS has the ability to significantly enhance SD performance, yet civil engineering organisations are failing to practice effective KS. Whilst a number of KS enablers and barriers have been identified in the review above, it is unclear which of these are most prominent when dealing with SD issues in civil engineering

contexts. The systematic review revealed relatively little research has been conducted in this area, thus warranting further investigation.

Consequently, the research reported in this thesis seeks to learn which, if any, of the typical barriers and enablers identified above hinder and enable KS for SD, respectively, and the extent of these within civil engineering organisations. It is hoped this will provide civil engineering organisations with a greater appreciation of the knowledge challenges they may face when developing high-performance SD systems, whilst also determining whether KS for SD exhibits any atypical characteristics.

CHAPTER 3
RESEARCH APPROACH

It is generally agreed that research is a process of enquiry and investigation, which is systematic and methodical, and aims to increase knowledge (Amaratunga et al., 2002). This chapter aims to address these aspects by presenting the process through which the research design was selected and crafted for purpose, and the subsequent data collection methods used to gather, analyse and interpret the case organisation's KS for SD.

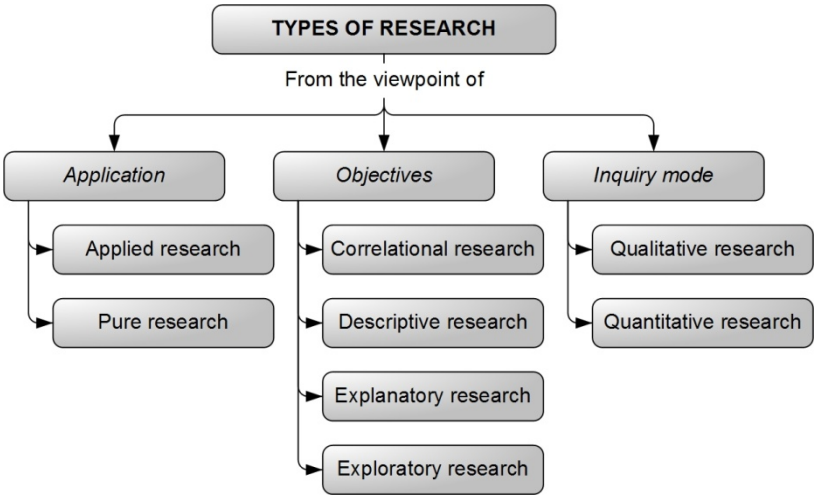
To begin, the underlying constructs of research and a number of common research designs are reviewed. A case study design utilising a mixed-method strategy is selected and justified in relation to the thesis' objectives, with a triangulation research model being adapted from the civil engineering management literature. Next, the three adopted data collection methods are presented and justified. The penultimate section presents the ethical considerations that encompassed the research approach. The chapter concludes by summarising the key aspects of the research approach.

3.1 RESEARCH PARADIGMS

Numerous research paradigms are cited throughout the literature. Kumar (2005) has classified these into three perspectives (Figure 3.1): *application* of the research study; *objectives* in undertaking the research; and *inquiry mode* employed. It is important to stress that these perspectives are not mutually exclusive (i.e. a research design is likely to comprise of research types from all three perspectives). The following three subsections briefly consider each perspective.

3.1.1 Application of the Research Study

There are two broad categories for the application of a research study; pure research and applied research (Kumar, 2005). Pure research (known also as 'basic' or 'fundamental' research) involves supporting and refuting theories and hypotheses; thus generating new scientific knowledge that describes what the world is like (Niiniluoto, 1993). According to Bailey (1978), pure research is "intellectually challenging to the researcher", yet may not have practical application at the present time nor in the future. A good example of pure research is Einstein's general theory of relativity.



Source: Kumar (2005)

Figure 3.1. Types of research

Applied research, by contrast, involves finding practical solutions to real problems, often by building on existing pure research. Consequently, the knowledge that is generated is often specific to its intended purpose (Niiniluoto, 1993). Most organisational research is conducted within an applied context (Bryman, 1989). Examples of applied research include: policy formulation, technology development, and seeking cures to illnesses.

3.1.2 Objectives in Undertaking the Research

The objectives of a research design can be broadly categorised as: descriptive; explanatory; correlational; or exploratory (Kumar, 2005). Descriptive research involves studying a problem, situation, phenomenon, etc., with the aim of identifying and describing what is prevalent in the study context. As such, it is heavily dependent on instrumentation for measurement and observation, which can take several years to develop (Knupfer and McLellan, 1996). Explanatory research is closely related to descriptive research; it aims to explain 'why and how' relationships between two variables or aspects of a study's context (Kumar, 2005). According to McNeill and Chapman (2005), "The distinction between descriptive research and explanatory research is often very blurred" – they are, to some extent, dependent on each other. Correlational research involves seeking causes of behaviour that can be attributed to correlations amongst variables (McBurney, 2001). However, it is important to note that a correlation does not equate to understanding cause and effect (Devlin, 2006). Finally, exploratory research is when a study has a clear purpose in lieu of a hypothesis or propositions (Yin, 2003).

This objective is often adopted when little is known about an area, sometimes to determine a focus for future research activities (Dixon et al., 1987, Kumar, 2005).

3.1.3 Inquiry Mode Employed

It is widely understood that research may be categorised into two distinct categories: quantitative and qualitative. Table 3.1 provides a summary of some of the fundamental differences between these two paradigms, whilst the following paragraphs discuss each in turn.

Quantitative research is based on positivism (Sale et al., 2002). It is a structured approach in which the research process is predetermined with the goal of quantifying social phenomena (Valsiner, 2000) in an objective (value-free) and reliable manner (McNeill and Chapman, 2005). To achieve this goal, adopted techniques include: randomisation; blinding; highly structured protocols; questionnaires with a limited range of potential responses; and large sample sizes (Sale et al., 2002). Its research process aims to develop a "testable hypotheses and theory which are generalisable across settings and […] is more concerned with how a rich, complex description of the specific situations under study will evolve" (Amaratunga et al., 2002). Despite there being numerous advantages to conducting quantitative research (e.g. cost, determining the extent of a phenomenon, ease of analysis (cf. Easterby-Smith, 1991), quantitative research has been criticised in the social sciences (Kaplan and Duchon, 1988). Reasons for this generally stem from a limited ability to ascertain richer underlying meanings and explanations of the phenomenon under scrutiny (Amaratunga et al., 2002). Nonetheless, Bryman (2006) somewhat refutes this by stating that the "imaginative application of [quantitative research] techniques can result in new understandings", thus counteracting the aforementioned drawbacks.

Qualitative research is concerned with understanding phenomenon without a predefined hypothesis (Devlin, 2006). This approach allows flexibility in the research process, enabling the researcher to explore the nature of a phenomenon (Kumar, 2005) by employing a wide range of interconnected interpretive techniques (Denzin and Lincoln, 2000). Such techniques include in-depth interviews and participant observation (Sale et al., 2002, Bryman, 1989), which are vivid, embedded in real-life contexts, and exhibit richness and holism that are useful in revealing complexity (Amaratunga et al., 2002). Consequently, there is increasing interest in qualitative methods in social sciences (Devlin, 2006) and in the civil

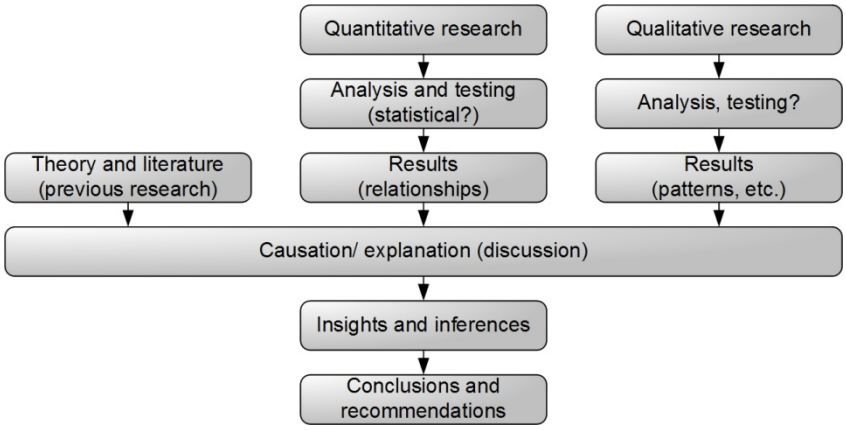
engineering domain (Amaratunga et al., 2002). However, positivists have exhibited resistance towards qualitative approaches, often arguing that such interpretivism (known also as 'post-positivism') is unscientific (cf. Denzin and Lincoln, 2000). Further drawbacks include: energy intensive data collection; complicated analysis and interpretation; and less control over research schedule (Amaratunga et al., 2002).

Table 3.1. Differences between qualitative and quantitative research

Difference with respect to:	Quantitative research	Qualitative research
Underpinning philosophy	Rationalism: "The human being achieve knowledge of their capacity to reason" (Bernard, 1994)	Empiricism: "The only knowledge that human being acquire is from sensory experiences" (Bernard, 1994)
Approach to inquiry	Structured/ rigid/ predetermined methodology	Unstructured/ flexible/ open methodology
Main purpose of investigation	To quantify extent of variation in a phenomenon, situation, issue etc.	To describe variation in a phenomenon, situation, issue etc.
Measurement of variables	Emphasis on some form of either measurement or classification of variables	Emphasis on description of variables
Sample size	Emphasis on greater sample size	Fewer cases
Focus of inquiry	Narrows focus in terms of extent of inquiry, but assembles required information from a greater number of respondents	Covers multiple issues but assembles required information from fewer respondents
Dominant research value	Reliability and objectivity (value-free)	Authenticity but does not claim to be value-free
Dominant research topic	Explain prevalence, incidence, extent, nature of issues, opinions and attitude; discovers regularities and formulates theories	Explores experiences, meaning, perceptions and feelings
Analysis of data	Subjects variables to frequency distributions, cross-tabulations or other statistical procedures	Subjects responses, narratives or observation data to identification of themes and describes the data
Communication of findings	Organisation more analytical in nature, drawing inferences and conclusions, and testing magnitude and strength of a relationship	Organisation more descriptive and narrative in nature

Source: Kumar (2005)

As implied above, these two paradigms are often discussed as if they're opposing alternatives, battling for dominance (Valsiner, 2000). However, both exhibit strengths and weaknesses, with neither one being superior to the other in all respects (Kumar, 2005). As such, research that integrates these paradigms has become increasingly popular in recent years (Bryman, 2006, McNeill and Chapman, 2005), and are commonly known as mixed-methods (or alike). This integrated approach has been shown to generate greater value (Kaplan and Duchon, 1988) and is believed to provide a more robust approach in civil engineering management research (Love et al., 2002, Amaratunga et al., 2002, Wing et al., 1998); Figure 3.2 presents an exemplar mixed-method research model.



Source: Amaratunga et al. (2002)

Figure 3.2. Triangulation of qualitative data

3.2 AVAILABLE RESEARCH DESIGNS

A research design is a blueprint that depicts the framework and strategy employed by a researcher in order to answer a research question validly, objectively, accurately and economically (Kumar, 2005). Numerous research designs are available. Titles and definitions of such designs vary throughout the literature, often exhibiting fuzzy boundaries and overlap. Yin (2003) provides a set of five widely recognised designs (experiment, survey, archival analysis, history, and case study) and describes the situations for which each should be used (see Table 3.2). Whilst there are numerous other less well known designs (e.g. feminist research, survey research, cohort studies, blind studies (cf. Kumar, 2005, Bryman, 1989)), action research is a widely recognised design (McNiff and Whitehead, 2002) which is often used in EngD research programmes. The following subsections briefly consider these six mainstream research designs.

3.2.1 Experiment

The experiment is important in organisational studies; it is often perceived as a model research design that allows the researcher to make strong claims about causality (Bryman, 1989) by determining "the effect that a change in one variable has upon another" (Dixon et al., 1987). It is, by virtue, the classic approach of the natural scientist (McNeill and Chapman, 2005).

Experiment design is often regarded as being either 'true' or 'quasi'. True experiment is where the researcher carries out research in a 'controlled' environment (Kumar, 2005) (e.g. a laboratory), where they have complete control over the who, what, when, where and how (McBurney, 2001). A drawback to

adopting true-experiment design is that measuring a predetermined set of variables in a controlled way means that the phenomenon under scrutiny is divorced from its context (Yin, 2003); it therefore generally exhibits low external validity (i.e. true experiment is less useful in establishing more generalised understanding). Quasi-experiment overcomes this lack of generalisation by the researcher relinquishing a degree of environmental control by not randomly assigning study participants to groups – they remain in their natural environment and/ or configuration (e.g. in predefined teams). As such, quasi-experimental design is often favoured over true experiment in interpretive social sciences as they are often conducted in the field (Bryman, 1989, McNeill and Chapman, 2005).

Table 3.2. Relevant situations for different research designs

Strategy	Form of research question	Requires control of behavioural events?	Focuses on contemporary events?
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes
Archival analysis	who, what, where, how many, how much?	No	Yes/ No
History	how, why?	No	No
Case study	how, why?	No	Yes

Source: Yin (2003)

3.2.2 Survey

Survey design is not simply comprised of a data collection instrument; it's a "comprehensive system for collecting information to describe, compare or explain knowledge, attitudes and behaviour" (Pfleeger and Kitchenham, 2001). Bryman (1989) defines survey design as entailing "the collection of data […] on a number of units and usually at a single juncture in time, with a view to collecting systematically a body of quantifiable data in respect of a number of variables which are then examined to discern patterns of association". Consequently, survey design is regarded as scientific, with positivist researchers often advocating their use (McNeill and Chapman, 2005).

The survey design is useful when describing the "incidence or prevalence of a phenomenon or when it is to be *predictive* about certain outcomes" (Yin, 2003). This is predominately achieved through obtaining a quantitative picture of how people vary in relation to a predetermined number of collected measures (Bryman, 1989). As such, in addition to questionnaires this research design may also employ interview and focus-group data collection methods (McNeill and Chapman, 2005). However, whilst survey design is often economical, it is also exposed to potential sampling, questionnaire design and survey response 'errors' (known also as

'biases') (Umbach, 2004, McBurney, 2001), which can greatly affect the validity and reliability of the results.

3.2.3 Archival Analysis

Archival design typically comprises of examining and extracting existing factual data relating to specific variables (Devlin, 2006). This design is appropriate where data exists that is directly relevant to a hypothesis, thus reducing the economic requirements associated with collecting new data, and where ethics or logistics make it infeasible to experiment with the variables of interest (e.g. in the case of sex crimes) (McBurney, 2001). Examples of archival data include: service records; organisational records; maps and charts; lists; survey data; and personal records (e.g. diaries) (Yin, 2003). However, researchers must be cautious when relying on archival data as they are "at the mercy of any biases that may have occurred in collecting the data" (McBurney, 2001).

3.2.4 History

A history design is similar to archival analysis in that the research is solely dependent on existing evidence. However, unlike archival analysis, it is based on the notion that the phenomenon under scrutiny is in the 'dead' past; i.e. "when no relevant persons are alive to report, even retrospectively" (Yin, 2003); this means the researcher has little or no access to or control over the phenomenon. Historians categorise artefacts into primary sources (e.g. personal notes, instruction manuals, diaries, eyewitness accounts) and secondary sources (the analytical and interpretive outputs from other historians and researchers) (Green et al., 2002). It is important to note that history research does more than detail the past; it helps to generate meaning about the present (Rousmaniere, 2004).

3.2.5 Case Study

Robert Yin, a leading case study practitioner and author, provides the following comprehensive definition of case study research:

> "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. […] The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from

> the prior development of theoretical propositions to guide data collection and analysis." (Yin, 2003)

Despite the term 'case study' implying the analysis of a single case (e.g. Kumar, 2005, Dixon et al., 1987, Stake, 2003), they can focus upon numerous cases (e.g. different groups or organisations) (Bryman, 1989). Adopting a multi-case design can improve the finding's external validity, though this is often not a goal in case study research (Hays, 2004). Furthermore, Yin (2003) states that case study design may be either holistic or embedded. The holistic approach analyses the case in its entirety, whereas the embedded approach samples and analyses sub-units with the aim of generalising the findings to the larger case. However, both of these exhibit weaknesses: the holistic approach is often conducted at an abstract level, thus lacking clear measures or data; whereas the embedded approach may prove too focused and thus fail when the findings are generalised to larger aspects of analysis (Yin, 2003, Shahalizadeh et al., 2009). Stake (2003) similarly identifies three types of case study design: intrinsic (the researcher wants a richer understanding of a particular case); instrumental (a case is examined to predominately understand an issue or to assess a generalisation); and collective (a number of cases are examined to investigate a phenomenon, population or general condition).

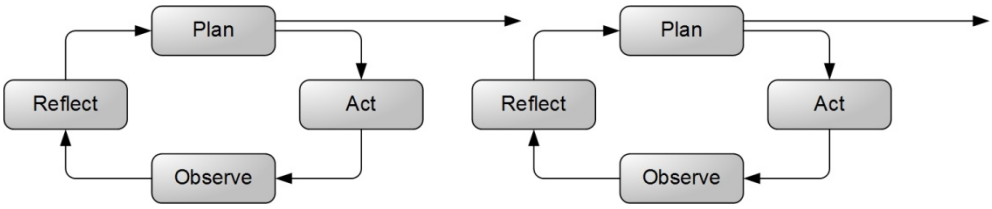
Case study designs commonly employ mixed-method approaches (Bryman, 1989), allowing the researcher to address a wider range of issues (Yin, 2003). As briefly discussed in Section 3.1.3, this integrated inquiry mode can be used in a "complementary fashion to enhance interpretability" (Green et al., 2002), enabling the researcher to bolster the reliability of the overall findings (Stake, 2003) and overcome some of the common misconceptions of case study research (cf. Flyvbjerg, 2006, Bryman, 1989). Greene et al. (1989) identified five purposes of mixed-method approaches:

- Triangulation – "seeks convergence, corroboration, correspondence of results from different methods";
- Complementary – "seeks elaboration, enhancement, illustration, clarification of the results from one method with the results from other method";
- Development – "seeks to use the results from one method to help develop or inform the other method, where development is broadly construed to include sampling and implementation, as well as measurement decisions";

- Initiation – "seeks the discovery of paradox and contradiction, new perspectives of frameworks, the recasting of questions or results from one method with questions or results from the other method"; and
- Expansion – "seeks to extend the breadth and range of inquiry by using different methods for different inquiry components".

3.2.6 Action Research

Action research is "a form of practice which involves data gathering, reflection on the action as it is presented through the data, generating evidence from the data, and making claims to knowledge based on conclusions drawn from validated evidence" (McNiff and Whitehead, 2002). This research process is often cycled (see Figure 3.3) until the researcher or vision is satisfied (e.g. improved service performance). This flexible approach is underpinned by the assumption that change is an "inevitable and continuous process in social situations" (Somekh, 2006), which also encapsulates the researchers and practitioners who change through the process of learning. Collaborative partnership is an important aspect of action research as it's founded on a philosophy of community development (Kumar, 2005), thus the process is mutually governed by the researchers and practitioners (Somekh, 2006); if conflict exists between parties then it is unlikely that action research will be successful.



Source: McNiff and Whitehead (2002)

Figure 3.3. Sequences of action-reflection cycles

3.3 ADOPTED RESEARCH DESIGN

This section presents and justifies the adopted research design. As concluded in the previous chapter, this research programme aimed to learn the extent to which typical KS barriers and enablers influence KS for SD within civil engineering organisations. Opportunities for enhanced performance will also be identified to improve the existing situation within the case organisation and wider field. As such the overarching research question was: "How can the sponsoring organisation improve intra-organisational sharing of sustainable development knowledge?" This

research question was accompanied by a number of specific objectives which were agreed in consultation with the sponsoring organisation:

- Review existing KS for SD literature in the field of civil engineering;
- Explore intra-organisational KS for SD within civil engineering contexts, using the sponsoring organisation as an exemplar; and
- Provide recommendations for how KS for SD performance may be enhanced within the sponsoring organisation and wider civil engineering community.

To address the above research question a single case study design that employed a mixed-method approach. The rationale for selecting this design was founded on the following reasons:

- the author had good access to and engagement with the (sponsoring) case organisation, providing an appreciation of the context in which the research was conducted;
- it was acknowledged in the literature review that intra-KS should precede inter-KS (i.e. 'get your own house in order first') (Mohamed et al., 2009), thus a single case serves this purpose as the case organisation recognised it has difficulties drawing on existing internal knowledge;
- it allows the characteristics of KS for SD to be recognised and explored in context (e.g. instead of applying preconceived KS models it allows understanding to be grounded in the organisation's context and then discussed in relation to extant knowledge) – this is important as little research has been directly conducted in this topic area;
- mixed-method approaches are advocated in civil engineering management research (Love et al., 2002, Amaratunga et al., 2002) and are embraced in case study designs as they allow multiple paradigmatic perspectives which provide richer understandings and a better reflection of reality;
- case studies can be designed to account for time, economic and information constraints, unlike some other research designs (e.g. action research can require long evaluative periods, history research may reveal limited historic information) – this characteristic was vital when dealing with an organisation that exhibits a project-led culture;
- exploratory case study designs can evolve to encapsulate new information or discoveries (Yin, 2003), providing a desired degree of flexibility in a relatively unexplored area (Bryman, 1989);

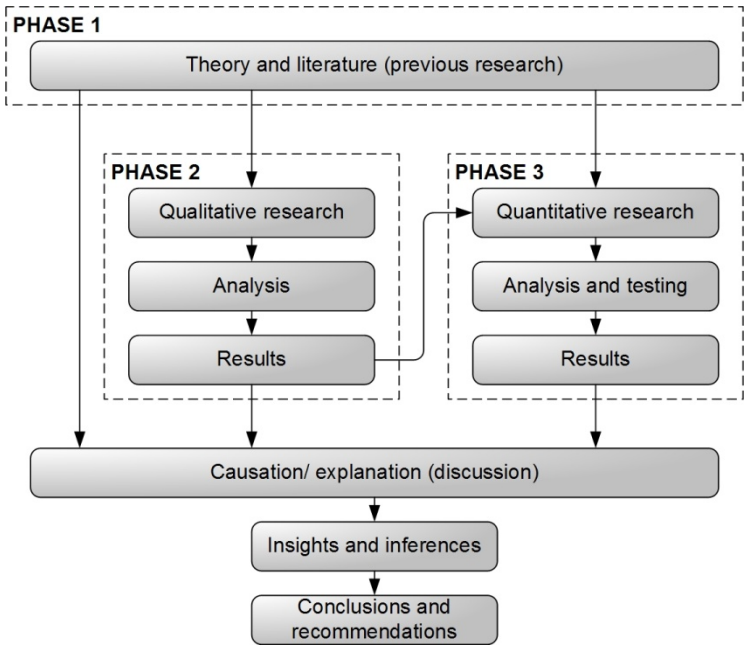
- case study design embraces applied research, which was vital to understanding the nature and context of KS and recognising potential opportunities for improvement in the case organisation;
- as Table 3.2 shows, case study focuses on contemporary events without requiring control of behavioural events; such control was not possible because of the potential consequences when dealing with project work (e.g. design errors, late delivery); and
- from an analysis of 160 KM articles emanating from ten leading information systems and management journals, Guo and Sheffield (2008) found that case study design was the second most common method in KM oriented research; the most common approach was sample survey.

Amaratunga et al.'s (2002) mixed-method model (Figure 3.2) was adapted for purpose as it clearly presents the research components and the application of qualitative and quantitative research. This model depicts three independent research streams (theory and literature, quantitative research and qualitative research), the outputs of which are discussed in relation to each other.

Three modifications were applied to this model, transforming it into the adopted research design (Figure 3.4). First, the model's 'triangulation' approach was substituted for a 'development' approach (cf. Greene et al., 1989); as no previous KS for SD research had been conducted within the case organisation, a development approach allowed the research to be underpinned by the exploratory research objective of exploring intra-organisational KS for SD. Furthermore, the development approach also allowed the findings from previous phases to influence the development of future phases (e.g. the findings from Phase 2 influenced the research undertaken in Phase 3). Second, the model was altered to reflect the sequence in which the activity phases were conducted. Third, the 'theory and literature' activity was not depicted as a standalone activity; it underpinned the qualitative and quantitative research.

Table 3.3. Summary of research activities

Overarching objective	Phase	Aims	Objectives	Methods	Key findings	Outputs
Review existing KS for SD literature in the field of civil engineering	1	Provide an understanding of the focal topics of the research programme	• Provide a state of the art survey of knowledge, KM, KS, SD and civil engineering fields • Consider KS, SD and civil engineering in relation to each other • Identify research needs and gaps in the existing body of knowledge	• Literature survey	• KS is integral aspect of KM, which is heavily governed by organisational culture • SD is highly complex and rapidly evolving • Civil engineering is increasingly urged to adopt more SD practices • KS can positively affect SD performance in civil engineering organisations	• Chapter 2
		Provide an overview of KS for SD peer-reviewed journal articles that exhibit civil engineering aspects	• Identify peer-reviewed journal articles that directly address the notion of KS for SD in a civil engineering context • Extract the KS concepts applied in a SD context • Extract the research strategies applied to address these concepts • Report and discuss the key findings from the identified studies	• Systematic literature review	• Low volume of existing KS for SD studies • Collaboration and education most commonly studied themes • Social networks perceived as important • Lack of intra-organisational studies	• Appendix A • Section 2.6
Explore techniques for KS for SD within civil engineering contexts, using the sponsoring organisation as an exemplar	2	Explore how SD knowledge is shared within the case organisation's communities	• Identify the enablers of KS for SD • Identify barriers to KS for SD	• Semi-structured interviews • Inductive QDA	• Eleven themes emerged from QDA • Three core KS for SD barriers identified: lack of organisational slack; poor SD ICT systems; and silo mentality	• Appendix B • Appendix D • Internal report and presentation
	3a	Explore and validate the lack of organisational slack and silo mentality KS for SD barriers identified in Phase 2	• Determine the level of intra functional SD connectivity • Determine the level of cross-boundary SD connectivity • Determine the effectiveness of SD relationships • Identify key players	• Questionnaire • Social network analysis	• A lack of organisational slack and silo mentality is not as widespread as Phase 2's findings implied • KS relationships are effective, despite infrequent interaction on SD matters	• Appendix C • Appendix D
	3b	Evaluate the SD portal's performance effectiveness and organisational members' intention to use it	• Assess the usability, design and information quality of the SD intranet portal • Determine the social influence of the SD intranet portal • Determine the perceived usefulness of the SD intranet portal • Determine users' behavioural intention of the SD intranet portal	• Questionnaire • Intranet assessment model	• SD portal can facilitate and catalyse KS for SD • Lack of awareness of SD portal • Those aware of the SD portal do not often use it • SD portal is easy to use and well designed • Need for more contemporary technical KS platforms	• Appendix D • Internal presentation



Adapted from: Amaratunga et al. (2002)

Figure 3.4. Adopted research design and research phases

To summarise, the approach used was evolutionary and interrelated; the findings from previous research phases directly contributed to the development of the next research phase. In other words, Phase 1 influenced Phase 2, and Phase 1 and 2 influenced Phase 3. These influences are explained in more detail when describing the research instruments in the next chapter. Whilst rationales for and details of the research instruments are provided later in the thesis, it is worth briefly summarising what was done. Phase 1 consisted of two literature surveys which draw on extant published knowledge. Phase 2 explores the barriers and enablers to KS for SD using semi-structured interviews and an inductive qualitative data analysis approach. Phase 3 explores three key barriers identified in Phase 2 by conducting two quantitative questionnaire studies: one which maps the SD social networks within three SGs; one which evaluates the quality and user acceptance of an intranet-based SD portal. The findings from all of the above research phases are discussed in relation to each other.

Table 3.3 provides a summary of the research activities in relation to the above first two objectives.

At this point it is worth considering the paradigmatic incommensurabilities associated with this mixed-method approach. After all, as Thomas Kuhn (1962) famously proposed in his *Theory of Scientific Revolutions*, it is possible to see the world in a very different way through a shift in paradigm. There has been much

debate surrounding the reconciliation of a pluralist mode of enquiry (cf. Burton and Kagan, 1998). Such debates invoke atypical methodological, ontological and epistemological challenges as there is a special focus on 'mixing' qualitative and quantitative research from the same study. However, in the present case such challenges are easier to reconcile because of the adopted 'development' approach. Unlike a triangulation approach, which seeks to converge on a common phenomenon, a development approach uses the findings from previous methods to develop and inform the next method, thus allowing the researcher to further explore areas of interest. This reduced the paradigmatic incommensurabilities as the 'mixing' of the data was less direct from a methodological standpoint; Phase 3 activities were shaped to further investigate the dominant findings from Phase 2, thus practically reframing the phenomenon under scrutiny within its respective paradigm. Nevertheless, Figure 3.4 clearly shows that the products from Phase 1, 2 and 3 are discussed in unison. In this instance an interpretivist stance was adopted; this allowed the author to gain insights and understanding by improving his comprehension of the whole through the continuous activity of juxtaposing elements of the undertaken research. It is noteworthy that this has ontological implications; the interpretations generated from juxtaposing the research elements is based on the author's construction of reality (cf. Sale et al., 2002), which ultimately affects the validity of the research.

3.4 DATA COLLECTION METHODS

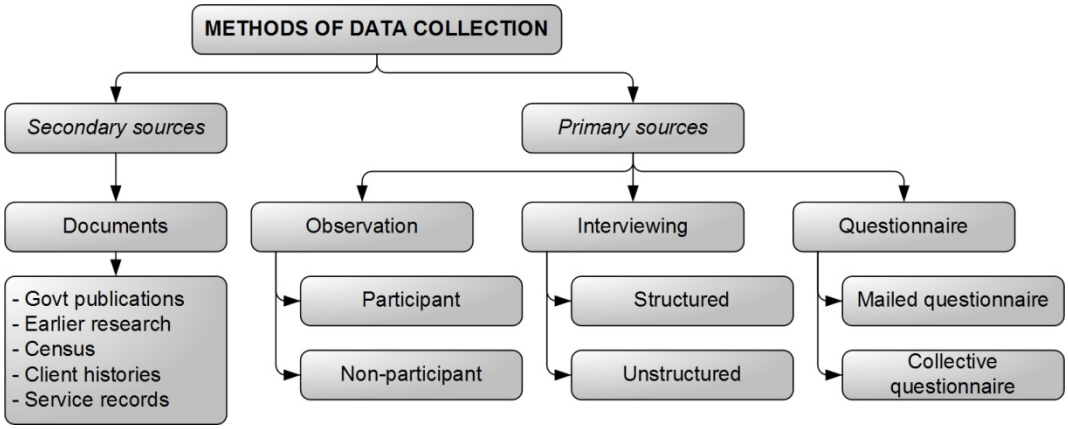
Evidence for case studies can be collected using a variety of methods whose data sources are either primary (i.e. first-hand information) or secondary (i.e. data that has already been collected from primary and/ or other secondary sources). Information from primary sources is typically collected using observation, interviews or questionnaires, whereas information from secondary sources is extracted from documents (see Figure 3.5).

Table 3.4. Summary of data collection methods for each research objective

Research objective	Data collection method
Review existing KS for SD literature in the field of civil engineering.	Secondary source: Literature review
Explore the existing KS for SD situation within the sponsoring organisation.	Primary source: Semi-structured interviews Primary source: Internet-based questionnaires
Provide recommendations for enhanced KS for SD performance within the sponsoring organisation.	Secondary source: Literature review

Three research methods were adopted to serve the research design presented in Figure 3.4. Table 3.4 shows how each of these methods serves each research objective. Observation methods were not used for numerous reasons which were

predominately rooted in resource constraints and knowledge barriers; e.g. the large number and geographic spread of organisational members meant it was highly possible that observational recordings would be incomplete, whilst directly and indirectly recognising technical KS for SD would require an in-depth understanding of specific civil engineering disciplines, which the author did not possess.



Source: Kumar (2005)

Figure 3.5. Methods of data collection

The following subsections describe each selected method in turn, explaining why they were selected and where they contribute. As the research design is exploratory in nature, further details about the development and execution of each method is provided in the next chapter; this is to avoid reader confusion by demonstrating the evolution of the research undertaken.

3.4.1 Literature Reviews

Two literature reviews of secondary sources were conducted for Phase 1 of the research design. An initial background literature review was used to build an understanding of existing research in the focal topics of the thesis, whilst a systematic literature review was used to identify and assess all journal articles that resonate with the focal topics. The outputs from these activities are reported in Chapter 2.

Background literature review

A background literature review is an essential and integral aspect of any research design. McNeill and Chapman (2005) assert that this is for three reasons: to provide ideas regarding research designs and strategies; to identify problems in the research proposal, thus avoiding repeat mistakes; and to ensure that the conducted research builds upon or relates to existing knowledge. Due to the exploratory nature of the

research design, it was decided that the review would survey the state of knowledge to provide an overview and the integration between relevant topics (cf. Baumeister and Leary, 1997). As such, a comprehensive literature review was conducted that primarily concentrated on KM, KS and SD, and their ties with civil engineering related disciplines.

Systematic literature review

Whilst it was clear that a plethora of KM, KS and SD related literature already existed, a systematic literature review was conducted to identify relevant KS for SD peer-reviewed journal articles that exhibited a civil engineering context. This was undertaken by adopting Tranfield et al.'s (2003) *stages of a systematic review*, with the aim of understanding which KS concepts had been applied, the research strategies used, and the key findings from the research. Unlike traditional literature reviews, systematic reviews aim to minimise bias by providing an audit trail of reviewers' decisions, procedures and conclusions (Cook et al., 1997, Petticrew and Roberts, 2005). This increases methodological rigour and helps to develop a reliable knowledge base from a range of sources (Tranfield et al., 2003).

3.4.2 Interviews

Interviews are a popular qualitative research method (Hannabuss, 1996) and are an essential source of information in case studies (Yin, 2003). Keats (2000) defines an interview as "a controlled situation in which one person, the interviewer, asks a series of questions of another person, the respondent".

The format of an interview resides on a spectrum between structured and unstructured. Structured (known also as 'formal') interviews are generally composed of closed questions that exhibit limited responses. This rigid approach is often likened with quantitative research and questionnaires (Bryman, 1989). By contrast, unstructured (known also as 'informal') interviews generally involve the interviewer having a set of topics to be addressed, instead of a list of predetermined questions. This more open conversational approach is favoured by interpretivists who argue that it provides more access to in-depth information and, consequently, a richer insight into particular phenomenon or experiences. However, it is recognised that the unstructured approach lacks standardisation making it complicated to draw comparisons between cases (McNeill and Chapman, 2005), whilst potentially weakening construct validity and external validity. Furthermore, this approach may

also inhibit the reliability of a study as personal factors, such as culture and mood, are likely to play a more significant role.

Between the two extremes of structured and unstructured interview lies the semi-structured interview which can employ a combination of closed and open questions. This hybrid approach often provides a degree of freedom to explore certain lines of enquiry and resolve any apparent contradictions, whilst gathering predetermined factual information to help navigate the interview and support comparisons between cases.

An interview structure was formed in collaboration with the case organisation. This adhered to deMarrais (2004) three guidelines for constructing interview questions, which comprise of:

- short, clear questions lead to detailed responses from participants;
- questions that ask participants to recall specific events or experiences in detail encourage fuller narratives; and
- a few broad, open-ended questions work better than a long series of closed-ended questions.

Consequently, the interview format exhibited characteristics that are more typical of an unstructured interview than one that was structured. Therefore, a semi-structured interview approach was used for the qualitative research in Phase 2. This provided the author with a greater degree of freedom to explore insights, opinions and attitudes, which better accommodated the exploratory nature of the research design.

The research instrument and the analytical process will be explained in more detail in Section 4.2.

3.4.3 Questionnaires

Questionnaires comprise of a set of printed unambiguous open and/ or closed questions, organised in a logical, systematic and engaging fashion, which are answered by respondents. If correctly designed and executed the results are considered objective and value-free, and are therefore advocated by positivists (McNeill and Chapman, 2005).

There are various approaches to administering questionnaires which are based on responses being solicited either via an interviewer or on a self-administered basis. The latter approach (known also as 'mailed questionnaires') is almost certainly the most widespread method of primary data collection, owing to numerous advantages including (cf. Bryman, 1989): it is an invariably more cost-effective method than observation and interview methods, especially for large and geographically dispersed populations and samples; they can quickly be administered (e.g. thousands of electronic questionnaires can be distributed within a very short space of time); and they eliminate interviewer bias and issues associated with interviewer presence (e.g. answering sensitive or personal questions) (cf. Couper, 1997). Questionnaires administered via an interviewer are similar to structured interview, and can be administered on a face-to-face basis or through the use of technology (e.g. telephone or video conference system). This approach is particularly useful when high response rates are necessary or when soliciting responses from particular populations (e.g. where participants are illiterate or disabled) (Kumar, 2005). Additionally, a face-to-face approach is especially useful when administering a questionnaire to a captive audience (known also as 'collective administration') (e.g. conference attendants or university students), whilst a technology enabled approach can provide wider geographic coverage and are more cost-effective than a face-to-face approach (McBurney, 2001).

Two questionnaires were developed and deployed to verify and explore the key findings from Phase 2. Consequently, Phase 3 was split into two independent research activities; one analyses the SD connectivity between organisational members, one evaluates the quality and user acceptance of an intranet-based SD portal. The questionnaires in both activities were deployed electronically using the internet. This means responses were solicited on a self-administered basis. These research instruments are explained in more detail in Sections 4.3.1 and 4.4.4.

Internet-based surveys are increasingly common in research because of their many benefits over conventional survey modes, including: speed of transmission; ease of analysis; respondent convenience; global reach; and dynamic functionality (Meese et al., 2010). However, they also exhibit some unique 'errors' that lead may lead to poor response rates. Whilst these are managed and evaluated in their respective activity, the issue of poor response rates within the case organisation was recognised early in the research programme. The following section elaborates on how the author investigated this matter to ensure his research did not succumb to

previous experiences when conducting questionnaire surveys in the case organisation.

Managing poor response rates

The case organisation had a prolific history of self-administered questionnaire surveys that experienced poor response rates. This became evident during an early collaborative scoping study for which the author and a fellow EngD researcher used an internet-based questionnaire to elicit SD needs from the case organisation's members. Despite deploying a wide-ranging marketing campaign and being live for 40 days, the questionnaire received a mere 1.65% response rate. Three fundamental questions emanated from this poor response: were sample members aware of the questionnaire (i.e. did the marketing campaign work)?; why did sample members who were aware of the questionnaire not complete it?; and did sample members who were unaware of the questionnaire feel they would respond if given the opportunity?

These questions were addressed using a telephone questionnaire, which allowed: direct access to any of the case organisation's members; a fast turnaround time; and management of any personal or technical issues associated with the internet-based questionnaire. A random sampling approach was used with the aim of obtaining a total of 65 responses. An initial set of 65 organisational members were randomly sampled from non-respondents of the internet-based questionnaire sample; after three failed contact attempts, the sample member was discarded and a new sample member was randomly selected. This resulted in a total sample of 108 members, thus a 60.2% response rate. However, three responses were unusable (attributable to language barriers and requests for written introductions), with an additional respondent claiming that they had responded to the internet-based questionnaire. This meant a usable sample size with n=61.

Findings from the telephone questionnaire revealed that 26 respondents were aware of the internet-based questionnaire. Reasons for these respondents' non-response were prosaic and were ranked as: a lack of time; a lack of relevance to their role; survey fatigue; and an inability to access the internet-based questionnaire. Of the 35 respondents that were unaware of the internet-based questionnaire, the majority stated that they would have completed the internet-based questionnaire (predominately to help company, out of curiosity, or because they always complete questionnaires), whereas 7 felt they would not complete it (reasons included lack of time, never completing surveys and unsure about the value of their input).

This investigation led to the development of practical guidance that aims to reduce data collection problems associated with internet-based questionnaires (Meese et al., 2010):

- request a senior organisational member who has direct involvement or interest in the study to act as a 'champion' – all communications regarding the internet-based questionnaire should be broadcast by this individual;
- clearly specify the population and its characteristics;
- if a random sample is not selected, clearly specify and justify the samples' selection;
- consider rewards (e.g. a prize draw) to encourage responses;
- always pilot the internet-based questionnaire on non-sampled population members before its deployment;
- ensure respondents can complete the questionnaire in less than twenty minutes (Umbach, 2004) and are aware of their progress (e.g. a progress bar indicating percent complete);
- if employing multiple marketing events, recognise which events lead to which responses – it may prove fruitful to compare responses from different marketing events;
- use follow-up reminders to produce higher response rates, but only remind those who are yet to respond;
- set aside time to investigate survey and item non-response – even if the response is high, these non-respondents may share a common issue which may require attention; and
- if the data to be collected is of great organisational importance, then mandating the internet-based questionnaire's completion is a way of ensuring a high response rate, though this should be a last resort.

This peer-reviewed study of internet-based data collection problems is reported in its entirety in Appendix E, providing further information about the conducted research and a discussion of the findings in relation to the surveyed literature.

3.5 EVALUATION OF THE RESEARCH DESIGN

This section presents the case study's evaluative criteria to establish its level of quality. According to Yin (2003), in case studies these typically comprise of: construct validity; internal validity; external validity; and reliability. These are

discussed in relation to the research design, whereas the research instruments are evaluated in situ with their design in Chapter 1.

Construct validity emanates from the research instruments' design, and is concerned with establishing how well the measures reflect concepts being studied (Keats, 2000, Yin, 2003). Whilst it is impossible to ensure construct validity (McBurney, 2001), it is possible to increase it by adopting a mixed-method approach, establishing a chain of evidence, and providing feedback mechanisms with key informants (Yin, 2003). It is believed that the research design exhibited a good degree of construct validity by adopting a mixed-method approach and, ultimately, establishing a chain of evidence by maintaining detailed records of all research activities.

Internal validity is only relevant to causal studies (e.g. an experiment research design) as it's concerned with the relationship between independent and dependent variables (McBurney, 2001). As such, internal validity is not relevant to the adopted research design.

External validity is concerned with whether the research findings can be generalised beyond the confines of the case study (cf. Lincoln and Guba, 2000). This can be strengthened through multiple-case designs (Yin, 2003). Flyvbjerg (2006) fiercely contests the common notion that it is not possible to generalise from a single case, concluding his argument with the following statement:

> "One can often generalize on the basis of a single case, and the case study may be central to scientific development via generalization as supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas "the force of example" is underestimated." (Flyvbjerg, 2006)

Despite the research design focusing on a single case organisation, according to this view it does exhibit a degree of external validity, especially in the relatively unexplored area of KS for SD in civil engineering.

Finally, reliability refers to the consistency of a research design to provide the same findings on different occasions (McBurney, 2001), thus minimising biases and errors in a study (Yin, 2003). Bryman (1989) asserts that this notion is comprised of two components: internal and external. Internal reliability refers to the degree of internal consistency of a research design (e.g. the difference between a test and retest), whereas external reliability refers to the degree to which a research design is

consistent over time. As the case organisation is constantly adapting to external market conditions by frequently modifying internal systems, the research design exhibited poor internal reliability. This changing environment also affects the external reliability; the exploratory nature of the design meant that certain findings influenced the development of subsequent research instruments, thus it is unlikely the design would remain consistent over time.

3.6 ETHICAL CONSIDERATIONS

The University of Bath is "committed to maintaining the highest standards of research excellence and integrity" (UoB, 2010), requiring all research in connection to the university to adhere to its 'Good Practice Code'. Furthermore, as KS is primarily embedded in sociology, the author also adhered to the British Sociological Association's 'Statement of Ethical Practice' (BSA, 2002). Codes of conduct, such as these, help researchers navigate the complex and often ambiguous ethical issues that can have a profound impact on people's lives (Stake, 2003, cf. Kennedy, 2005). Consequently, relevant principles from the abovementioned codes of conduct were assimilated by the author and embedded in the research design and underlying data collection methods. Emphasis was placed on communicating the research programme's purpose and findings honestly, whilst maintaining the anonymity, privacy and confidentiality of participants and collected data to ensure the research population's well-being (e.g. to avoid organisational members being mistreated as a consequence of the conducted research) (cf. Keats, 2000, Dixon et al., 1987).

At no point did the (sponsoring) case organisation attempt to constrain particular findings or conclusions (cf. Cheek, 2003). However, as a consequence of the global economic downturn that commenced near the beginning of and continuing throughout the research programme, the author experienced significant resource constraints that heavily impinged access to primary data sources, ultimately limiting his freedom to conduct desired research activities. As such, the research design was modified on several occasions in consultation with the author's academic and industrial supervisors. This ensured this evidently difficult situation was recognised and aptly managed to ensure the University of Bath's EngD requirements were fulfilled.

3.7 SUMMARY

This chapter began with a brief review of the three dominant paradigms that all research activities are founded upon: application of the research study; objectives in undertaking the research; and inquiry mode employed. Next, six mainstream research designs were reviewed. A mixed-method case study design was selected, with a triangulation research model being adapted from the civil engineering management literature (see Figure 3.4). Four evaluative criteria were then described and were discussed in relation to the research design; the research instruments presented in the next chapter will also be subjected to these criteria.

Data collection methods were then considered for Phases 1, 2 and 3 of the research design, with the following methods being selected and justified: background and systematic literature reviews; semi-structured interviews; and self-administered questionnaires. Thus, a combination of qualitative and quantitative data collection methods was used in conjunction with primary and secondary data sources, upon which the research instruments were designed (described in the next chapter).

Ethical considerations were then addressed in relation to the study with the author, research design and data collection methods adhering to the relevant principles of two ethical codes of conduct. Finally, funding difficulties and research constraints experienced during the research programme were expressed.

CHAPTER 4
RESEARCH UNDERTAKEN

The purpose of this chapter is to convey the evolution of the research undertaken in addressing the research programme's overarching aim and objectives, as described in Section 3.3. Using the adopted research design and selected data collection methods, a number of research instruments were designed and deployed to satisfy the programme's overarching requirements. Noteworthy, as the research design was exploratory in nature, most research instruments' development was influenced by the findings of previous research activities (as depicted in Figure 1.2). Further, when reference is made to an article in the appendices, it is recommended that the article is read in its entirety.

The layout of this chapter complies with the research design depicted in Figure 3.4. First, two research activities review the existing theory and literature. Next, the qualitative semi-structured interview design and findings are presented. The quantitative questionnaire activities are then presented, accompanied by explanations of how the qualitative research findings influenced their design.

4.1 PHASE 1: THEORY AND LITERATURE

This phase addresses the first overarching research objective: "review existing KS for SD literature in the field of civil engineering". To achieve this aim, two research activities were undertaken; a background literature review and a systematic literature review.

4.1.1 Background Literature Review

The aim of this research activity was to provide an understanding of the focal topics of the research programme. This aim was underpinned by three objectives:

- provide a state of the art survey of knowledge, KM, KS, SD and civil engineering fields;
- consider KS, SD and civil engineering in relation to each other; and
- identify research needs and gaps in the existing body of knowledge.

The output from this activity was reported in 0, with a summary of the findings provided in Section 2.7. This revealed a gap in the reviewed literature which expressed a need for KS for SD in civil engineering. During an early research scope

consultation with the case organisation, it was agreed that this need resonated with their requirements.

Sources of information were predominantly accessed using internet-based article search engines (e.g. Web of Knowledge, ScienceDirect, EBSCO and Google Scholar), and the libraries at the University of Bath and the University of Bristol. Emphasis was placed on peer-reviewed published works to ensure the sources' validity. However, only a small number of civil engineering oriented KS for SD sources were identified, thus leading to the second research activity in this phase.

4.1.2 Systematic Literature Review

In response to the lack of existing research that was directly linked to the focus of the research programme, the author conducted a systematic literature review with the aim of providing an overview of peer-reviewed journal articles that exhibit KS for SD in a civil engineering context. Thus, the following four research objectives were devised:

- identify peer-reviewed journal articles that directly address the notion of KS for SD in a civil engineering context;
- extract the KS concepts applied in a SD context;
- extract the research strategies applied to address these concepts; and
- report and discuss the key findings from the identified studies.

Using Tranfield et al. 's (2003) *stages of a systematic review*, the systematic review commenced with the identification of a holistic set of keyword terms that related to SD and KS, which were compiled by the author and seven subject experts (SEs). An exclusion criterion was also developed which described the study characteristics required to be included in the final set of studies. The keyword terms were subsequently concatenated into a search string, which was used to query five leading online article databases. A total of 17,469 results were returned which, by applying the systematic review stages, were whittled down to a final set of 20 studies.

A summary of this research activity is presented in Section 2.6. Further, this research activity is published in AI & Society: *Journal of Knowledge, Culture and Communication*, a copy of which is located in Appendix A.

4.2 PHASE 2: QUALITATIVE RESEARCH

As the case organisation had not conducted any direct research into KS for SD, it was agreed that the aim of this phase was to explore how SD knowledge is shared within the case organisation's communities. Two objectives underpinned this aim:

- identify the enablers of KS for SD; and
- identify barriers to KS for SD.

This research activity is under second review with a peer-reviewed journal, a copy of which is located in Appendix B and discusses the research process and findings in greater depth. However, a summary of the research undertaken and the key findings are reiterated here.

4.2.1 Research Instrument

The interviews were organised around the following five sections which aimed to satisfy the research objectives above:

- the interviewee's organisational background and perception of SD;
- enablers of and barriers to KS for SD;
- internal SD oriented communities;
- examples of good and poor KS for SD; and
- how the study organisation compares to its competitors in relation to KS for SD.

As aforementioned, a key benefit of the semi-structured interview approach is that it allows the exploration of interesting lines of enquiry raised by interviewees (Yin, 2003). However, to improve responses, all interview participants were sent an 'advanced briefing note' which described the purpose of the interview, the interview format, a confidentiality statement, and the interview sections to be discussed; thus the interview structure did not formally evolve in light of such of enquiries. This was managed by the interviewer maintaining notes of potential lines of enquiry, which evolved as the interviews progressed. A dictaphone was used to capture the interview audio, which was later verbatim transcribed.

Shaw (1999) asserts that the "…subjective epistemology of the qualitative research paradigm views social reality as constructed by humans and maintains that if it is to be understood, the researcher cannot remain distant from and uninvolved in the social phenomenon in which they are interested." Accordingly, the author used

himself as the 'research instrument', allowing him to explore participants' perspectives and get close to the data so that he was able to generate a comprehensive, grounded understanding of the problem area in relation to the research objectives.

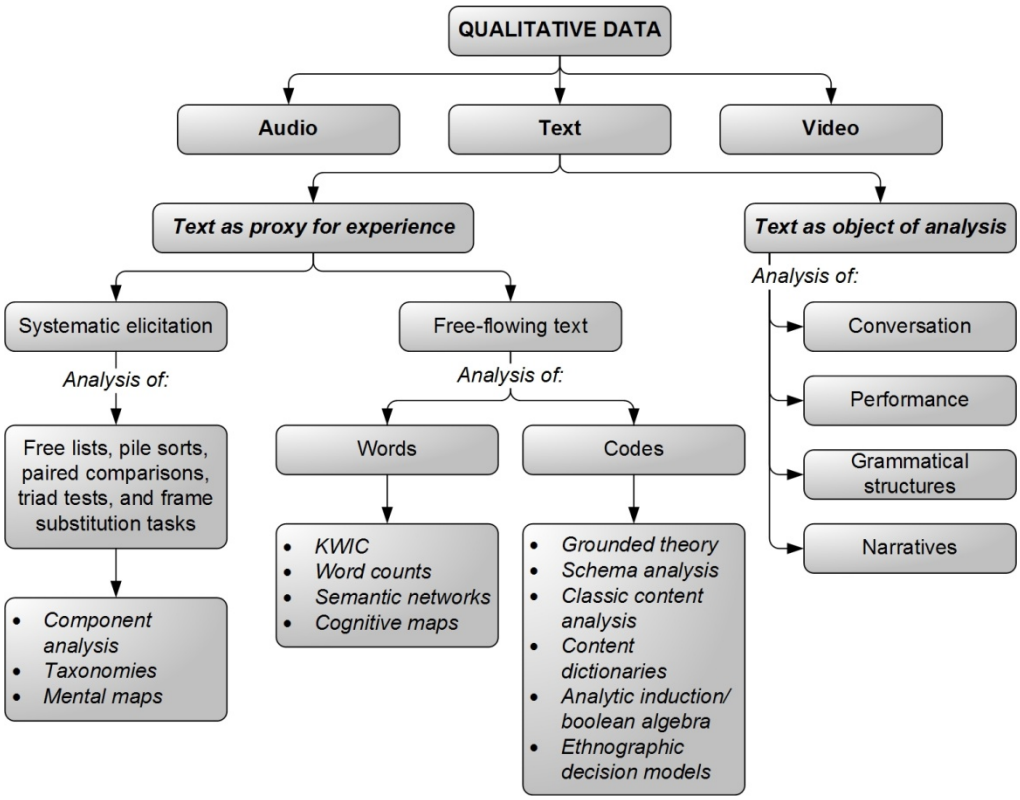
The target population comprised of all project-oriented organisational members. It was agreed with the study organisation that ten interviews would be conducted. As such a low volume of interviews was allowed, non-random purposive sampling was used to select interview participants who are actively involved with SD project work. This technique is useful when exploring an area for which relatively little is known and permitted the authors to collect rich data in the area about the substantive research aim (cf. Dixon et al., 1987, Kumar, 2005). To reduce sampling bias, secondary data from a SD oriented questionnaire formed the basis for participant selection. This data were organised to reveal the organisational members who were most commonly involved in SD oriented initiatives and are, thus, more likely to recognise the enablers and barriers that govern organisational KS for SD.

Qualitative data analysis

Figure 4.1 presents a typology of qualitative data analysis (QDA) methods with focus on textual data; outputs from the interviews were transcribed audio and interviewer notes. Whilst it is clear qualitative data can be analysed in numerous ways, the purpose of this sub-section is to provide the rationale for selecting an approach that serves the aims and objectives of Phase 2 whilst complementing the overall research design. To begin this process, this research phase is concerned with exploring the insights, opinions and attitudes of organisational members. As such, this section does not address the linguistic tradition which treats text as an object of analysis in itself.

When using text as a proxy for experience, researchers are presented with two kinds of written texts: words or phrases generated through systematic elicitation techniques; and free-flowing texts (e.g. narratives, discourse, responses to open-ended interview questions) (Ryan and Bernard, 2000). Systematic elicitation techniques generally analyse short phrase or word responses to questions such as: "Which is better for sharing knowledge, interpersonal interaction or information technology systems?" or "What kinds of reward systems existing with your organisation?" Whilst these systematic techniques can provide valuable insight into cultural domains, they are somewhat limited by the need for a prescribed approach,

thus limiting flexibility and exploration of meaning. Free-flowing textual data typically does not exhibit this limitation.



Source: Ryan and Bernard (2000)

Figure 4.1. Typology of qualitative analysis strategies and methods

Ryan and Bernard (2000) assert that analysis of free-flowing text can be analysed by either its "most basic meaningful components: words" (i.e. content analysis) or by the meanings found in blocks of text (i.e. thematic analysis). The former approach looks at the words individuals use to build understanding; for example, counting the number of repetitions of all words within a transcript. More advanced techniques draw on disciplines such as linguistics to develop richer insights. It is noteworthy, however, that these techniques typically introduce an element of quantification, thus translating qualitative data into quantitative understanding. This is demonstrated by the number of software packages with dedicated word analysis functions. Nonetheless, some authors advocate their use as a first step to coding large volumes of qualitative data (Ryan and Bernard, 2003). This may prove especially useful to researchers who are not 'close' to the data or involved with its collection (e.g. analysis of secondary qualitative data). Extracting meaning from blocks of text is predominately achieved through inductive coding, and is almost certainly the most common QDA technique. Its aim is to identify and

describe explicit and implicit ideas, which can produce valuable context-rich insights to the area under study (Namey et al., 2008).

Table 4.1. The coding process in inductive QDA

Initial reading of text data	Identify specific text segments related to objectives	Label the segments of text to create categories	Reduce overlap and redundancy among the categories	Create a model incorporating most important categories
Many pages of text	Many segments of text	30 to 40 categories	15 to 20 categories	3 to 8 categories

Source: Thomas (2006)

Whilst inductive coding can reveal richness in understanding that is unbeknownst in quantitative research, it is often advocated that such approaches are performed by veteran researchers because of its demanding nature. However, Thomas (2006) recognises this barrier and presents a *general inductive process* which aims to provide a systematic approach that aims to reduce such challenges by providing a clearly marked process (cf. Table 4.1). Its strategy is to identify the core meanings evident in the text, producing a small number of summary categories that are considered most relevant to the research objectives. The coding process is comprised of the following five steps:

1. Preparation of raw data files: clean the data and format it in a common format.
2. Close reading of text: assimilate the data until familiar with content and dominant messages.
3. Creation of categories: identify and define categories (or themes); upper-level categories are derived from research objectives; lower-level categories emerge through close interaction with the data (known also as 'in vivo coding'); different coding procedures may be adopted.
4. Overlapping coding and uncoded text: segments of data may be categorised more than once; a large proportion of the data (50% or more) is likely to not belong to a category (uncoded) because of a lack of relevancy.
5. Continuing revision and refinement of category system: seek supporting or contradictory points of view and insights; select quotes that reflect or convey the essence of the category; categories may be linked or combined when their meanings are similar.

This process encourages the adoption of different coding procedures (Step 3) to suit the needs of the researcher. Glaser and Strauss's (1967) constant comparison analysis (CCA) coding procedure was adopted for this purpose. CCA is almost certainly the most widely used inductive coding procedure and is particularly

effective when attempting to answer "general, or overarching, questions of the data" (Leech and Onwuegbuzie, 2007). Glaser (1992) eloquently asserts that the CCA method "…gets the analyst to the desired 'conceptual power quickly', with ease and joy. Categories emerge upon comparison and properties emerge upon more comparison. And that is all there is to it." Thus, the researcher is required to constantly revisit previous codes to determine whether they resonate with the current block of data under scrutiny; this ensures that similar blocks of data share the same code and enables the researcher to recognise the various facets of each code. Categories then emerge by subsuming codes that are conceptually similar or different. This systematic process of fracturing, connecting and integrating the data continues until the data is exhausted for purpose; no further codes or categories emerge and no further analytical refinement is required.

Evaluation of the research instrument

The criteria used to evaluate the research design in Section 3.5 are conventionally defined within the positivist paradigm. As this research instrument employs a post-positivist paradigm, the author adopted Guba and Lincoln's (1989) parallel judgement criteria (known as 'trustworthiness'). This widely cited post-positivist evaluative criteria parallels the positivist criteria by coupling internal validity, external validity, reliability and objectivity with credibility, transferability, dependability and confirmability, respectively. The following addresses each trustworthiness criterion in turn.

Credibility refers to "establishing the match between the constructed realities of respondents (or stakeholders) and those realities as represented by the evaluator and attributed to various stakeholders" (Guba and Lincoln, 1989). It was addressed through an internal debriefing report and presentation. This provided an opportunity for stakeholder groups (i.e. interview participants and management teams) to verify the findings and feedback any suggestions or concerns; it revealed that there was general agreement from a wider-audience surrounding the key messages and core KS for SD barriers.

Transferability is established through 'thick description' (Guba and Lincoln, 1989). Thus, it is the responsibility of the study's recipient, not researcher, to assess the contextual overlap between the study's conditions and the conditions of the targeted transfer. As the case organisation wished to remain anonymous, the thick descriptions provided in this section and the organisational overview in Section 1.2

is ultimately limited. Thus, individuals seeking to transfer the findings from this phase should exercise caution.

Dependability accounts for methodological evolution as part of the post-positivist paradigm; i.e. the researcher's worldview will evolve in conjunction with the study's development, thus the methodology will also shift and evolve to encompass new insights and understanding. Confirmability works in situ with dependability to ensure that a study's findings are not the figments of the researcher's imagination.

4.2.2 Key Findings

Sixty-six codes were initially identified in the interview transcripts; these were organised into eleven categories. Table 4.2 presents a summary of the themes and key messages that emanated from the QDA process. Through the process of constant comparison, three core barriers emerged that were believed to hamper the effectiveness of KS for SD. These are: lack of organisational slack; poor SD ICT systems; and silo mentality. Despite numerous enablers of KS for SD being expressed by the participants (e.g. positive attitudes towards KS and SD), it seems their benefits are often thwarted by the core barriers. This is not to suggest that these enablers never prevail or that there aren't other factors which contribute to the effectiveness of KS for SD. Nonetheless, the core barriers permeate the interview data, being recognised for creating or exacerbating KS issues whilst negating the enablers of KS for SD.

Table 4.2. Summary of themes and key messages from interview analysis

Theme	Key messages
Communication culture	• Open communication between peers • Poor communication between SGs • Introductory 'handshaking' process is ideally adopted to avoid disgruntling first contact with peers • Lack of feedback surround SD proposals and solutions prevents members from validating their SD knowledge
Cross-boundary KS	• CoPs aim to cut across functional boundaries • Poor awareness of SD activities within other functional groups • Organisational structure has generated a silo culture
Funding	• KM related time code allocated to MBFs • No immediate KM time code benefits had been recognised • Projects that earn more money are able to train their members to higher standard in SD issues • Poor awareness of central funding schemes
KS techniques: Social interfacing	• Interpersonal approaches were the favoured KS technique • Regular lunchtime seminars are a key informal KS activity • Numerous formal interpersonal KS activities, including: CoPs; conferences; and mentorship programmes

	• Time is a limiting factor in engaging in informal KS activities
KS techniques: Technical systems	• Perceived as useful for connecting organisational members • Skills and experience database isn't configured to seek SD knowledge sources • Discussion site is not effectively used; the organisation is concerned about people wasting their time • Lack of time means organisational intranet system isn't delivering validated, up to date information • KS via video conference technology is limited by the need to have formal agendas and protocols to ensure effective communication.
Leadership	• Upper management are encouraging KS in response to SD issues • Bottom-up SD leaders are recognised for driving forward initiatives • Lack of empowerment for SD leaders is hindering their success
Motivation	• Participants felt KS for SD is a personal driver • Reward system disincentivises cross-boundary KS
Personal networks	• Recognised as playing a fundamental role in seeking knowledgeable sources and effective KS • Useful for informal impromptu KS • Locality of network peers is deemed a KS performance factor
Staff attitude: KS	• Good appreciation of KS • Participants recognise the value of KS for SD • Lack of time to share knowledge generated frustration
Staff attitude: SD	• Positive attitudes towards SD • Not all organisational members exhibit an enthusiasm for SD • Difficult to keep abreast latest SD developments • Organisational structure and culture may resist necessary changes to embrace the needs of SD
Time	• Time is constraining both formal and informal KS • Project led culture negates all non-fee earning activities • Time booking system inhibits KS

Lack of organisational slack

Participants repeatedly made reference to the lack of organisational slack when engaging in formal and informal KS for SD. This seems to stem from the organisation's culture, which perceives all non-fee earning work as a secondary activity; i.e. any activity not directly associated with project delivery, such as KS, was deemed a non-priority activity. This is common amongst civil engineering consultancies (Fong, 2005). Furthermore, this is compounded by a time booking system, which requires all organisational members to book their time against a budget code. This means that if an organisational member possesses sought after SD knowledge, they often require a management-agreed budget code to cover their KS time and costs (e.g. travel).

Table 4.3. Functions of slack in corporate greening

Function of slack	Operation in corporate greening context	Unit of analysis
Inducement (to maintain coalition)	• firm's environmental reputation is a potential side-payment to retain cooperation from managers and employees – do not want to work for poor performers • environmental improvement as a personal incentive in some professions, e.g. water and chemical engineers • other side-payments (e.g. share options) provide incentives to implement only win-win or short-term environmental initiatives	Individual (both top management and employees)
Conflict resolution	• environmental 'pet projects' with a low return supported where available slack allows them to be easily pursued • operating units do not bother suggesting environmental improvements with up-front costs in low available-slack circumstances	Sub-unit
Workflow buffer	*Slack resources form an internal buffer to cope with increased environmental demands...* • having more people trained in environmental issues than required for day-to-day running of business to cope with crises • paying excess prices for inputs leading to higher environmental standards • buying more expensive equipment than strictly required resulting in improved environmental performance such as lower emissions or fuel optimization • over-resourcing supplier environmental certification process *Slack resources can also form an external buffer...* • initiating and managing relationships with external constituents such as regulators, legislators or local residents	Organization (internal and external)
Innovation	• absorbed slack, in form of higher corporate overheads, allows larger central environmental groups. These act as search teams for new environmental technologies and legislation *Slack facilitates innovative behaviour such as...* • market research through environmental surveys • speculative market testing of eco-labelling products • experimenting with more environmentally sound • speculative development of greener products	Organization
Satisficing	• in high-slack situation, less urgent need for environmental responsiveness leads to less extensive search for greener technologies • in low-slack situation, more intensive search for win-win environmental initiatives, e.g. packaging reduction, emissions reduction	Organization or top management team
Politics	• environmental managers cooperating with health and safety managers to try to gain more organizational resources (internal political activity) • in high-slack situation, able to take part in political activity external to firm, e.g. committee work with trade associations, environmental associations, governmental bodies, select committees and so on	Organization or top management team (internal and external)

Source: Bowen (2002)

Organisational slack provides latitudinal freedom which enables organisations to seek creative solutions to SD issues (Bansal, 2005). Mohn (2006) expresses linkages between environmental performance and resources, such as the concept of slack. Further, Strike et al. (2006) imply that the availability of slack is an indicator

to the extent organisations are willing and able to invest in SD related activities. Environmental researchers argue that slack needs to be easily mobilised in the short-term (Bansal, 2005); this has been shown to permit faster responses to more immediate opportunities and threats (Bansal, 2003). This proactive approach has the potential to generate significant strategic advantages (Bran et al., 2010). However, slack is typically a characteristic of large high-performing organisations (Bran et al., 2010). Those organisations that lack organisational slack are unlikely to fully commit to SD practices (Bansal, 2005). Table 4.3 presents the findings from a study conducted by Bowen (2002) on the function of organisational slack in environmental management. Based on these findings, Bowen (2002) argues that organisational slack is an important factor in this area despite the benefits being difficult to immediately and readily identify.

Interpersonal KS activities were advocated by the interview participants as they provide important face-to-face interaction. The organisation has a number of formal KS for SD activities, including: 'working groups' (a form of community of practice); conferences and forums; training days; and a mentorship programme. A fundamental advantage of these is that the case organisation often supplies a budget code for organisational members' participation. However, more informal activities were more popular amongst the interview participants, amongst which lunchtime seminars were the most commonly cited activity. Lunchtime seminars consist of organisational members volunteering to present their work, research or area of interest whilst attendees eat their lunch. Participants enjoyed and capitalised on the rich discussions and networking opportunities that emerged from these seminars, often using newly acquired SD knowledge in their project work. However, they also conceded that a lack of time was increasingly preventing them from engaging in informal KS activities; in other words, there is a limited amount of personal time that they've available or are willing to invest in such activities.

These findings suggest that the lack of organisational slack has created environment where reactive KS supersedes proactive KS; i.e. organisational members only seek knowledge in response to a particular situation. This symptomatic approach is considered unsuitable for SD, which requires a more systematic approach to manage its complex dynamic nature (Godfrey, 2010).

Poor SD ICT systems

The case organisation's poor ICT systems do little to support organisational members in keeping abreast of the rapid evolution of SD knowledge. Although participants preferred interpersonal activities, ICT systems offer numerous advantages, which were generally recognised by the participants (as outlined below).

Mohamed et al. (2010) assert that "ICT is critical for sustainable development […] due to the geographical separation and multifaceted nature of international sustainable development, it cannot be carried out without ICT's support." Dalal-Clayton and Bass (2002) also suggest that on-demand access to knowledge and information is a precondition for SD. However, awareness of such resources is also crucial; i.e. you need to be aware of resource before you can engage with it. Creating and maintaining this awareness is difficult in large international organisations, especially as SD resources are highly dynamic and interrelated. ICT systems can support KS for SD in numerous ways, namely the lowering cross-functional and -geographic barriers (alleviating the perception of isolation) and reduce uncertainty surrounding decision-making (Mohamed et al. 2009).

Five ICT systems were cited as supporting KS behaviour, comprising of: an intranet system; an electronic discussion site; a skills and experience database; email; and video conference (VC) technology. The case organisation's intranet system was the most commonly cited system, generally as a consequence of its poor effectiveness. A dominant barrier to this effectiveness was the time required to maintain the intranet's content, whilst some concern was raised regarding the lack of content validation to avoid misinformation and poor or outdated practice. Furthermore, whilst the intranet did host SD content, there was a lack of SD focus; i.e. SD content was spread wide and thin. Two participants proposed an intranet based SD 'portal' would provide better KS for SD support by linking all the latest available SD resources, thus providing a single point of access to all electronic SD content (e.g. guidance documents and news items) and resources (e.g. SD specialists and communities of practice) within the case organisation.

The intranet site hosted two widely cited KS systems: a skills and experience database and a discussion site. The first system, the skills and experience database, enabled organisational members to seek peers with particular knowledge. However, there were no dedicated SD categories, making locating SD peers significantly more

complicated; thus, participants usually resorted to their personal networks to seek SD knowledge from their peers. The second system, the discussion site, was infrequently used; a barrier in itself. This was verified in an EngD assignment.

Unfortunately, the participants exhibited poor engagement with the abovementioned ICT systems. This seems to stem from a lack of trust in organisational ICT systems, which is contrary to the finding that interpersonal trust is ubiquitous in the case organisation. Davenport and Prusak (2000) proclaim that weak trust in technical systems is often the result of individuals' confidence level in the quality of knowledge, which resonates with the finding that some organisational members want greater validation of electronic content. Consequently, it is unlikely that organisational members will exhibit confidence in content which has previously proven invalid. In addition, the lack of reciprocity with ICT systems results in an interaction which is "often less inhibited than face-to-face exchanges and may lead to greater conflict and misunderstanding" (Rogers, 2003).

Silo mentality

Participants repeatedly expressed a lack of cross-boundary KS. Whilst the lack of organisational slack and poor ICT systems seem to be compounding this barrier, the organisational structure and reward systems seem to also work against cross-functional and cross-geographic KS. Traditional organisational structures, such as that exhibited by the case organisation, are commonly adopted by engineering and construction organisations. However, whilst these may lead to excellence in expertise, they tend to blight innovation, encourage routine activity and reduce staff challenges (Kini, 2000, Rogers, 2003). In addition, although personal networks are perceived as a vital aspect of KS for SD, it was recognised that personal network relationships are stronger with contacts who were physically closer (e.g. in the same office). This meant that more distant personal network peers' require more time and energy to maintain a good KS relationship.

Silos are the antithesis of integration, which means they can have substantial implications for SD. As aforementioned, SD requires a holistic view of each project to configure different strategies that create a coherent set of integrated SD goals (Brand and Karvonen, 2007). Silos make it difficult to manage changes, mitigate risks and contain costs, especially in civil engineering organisations that typically exhibit fragmented functionally (Robichaud and Anantatmula, 2011). This lack of boundary permeability can limit communication and cooperation between SD

practitioners (Dalal-Clayton and Krikhaar, 2007). Under such circumstances, unintended consequences may emerge: the result of a lack of understanding of how the product (e.g. building, port) works as a system rather than as a set of components.

The interviews also revealed that some extrinsic reward systems are inadvertently encouraging organisational members to hoard knowledge for competitive advantage. For example, if cross-boundary KS improved a project's delivery, the extrinsic reward may not be shared with non-project members who sent or applied the knowledge which contributed to the rewarded success. This seems to negate the development of a culture where KS is the norm (Milne, 2007).

The abovementioned cross-boundary KS issues seem to have created a silo mentality, where organisational members often exhibit a poor awareness and appreciation for activities outside their respective functional and geographic silos. This comprehension meant some participants brought into question whether the case organisation had the ability to deliver integrated SD solutions; i.e. whether the organisation had the ability to shy away from existing its organisational forms and project culture, and move towards ways of working that inherently support SD.

4.2.3 Phase Summary

This second phase has reported on the qualitative research undertaken in accordance with the research design (Figure 3.4); Appendix B reports this phase in its entirety. A series of semi-structured interviews were conducted with key informants within the case organisation. Using inductive QDA a number of key messages emerged from the interview data. The findings suggest that in large international civil engineering organisations, such as the case organisation, effective KS for SD will not happen by itself. SD is almost certainly the most complex issue civil engineering has ever faced. This research phase reinforces the notion that effective KS is fundamental in achieving superlative SD performance.

In line with the phase's research objectives, barriers to and enablers for KS for SD were identified. Three core barriers are presented that are likely to constrain KS for SD, principally because of SD's complex, dynamic and interdisciplinary nature. Although the barriers themselves are somewhat prosaic, they provide focus for civil engineering organisations wishing to improve their KS for SD, negating the need to consider the extant panoply of KS barriers. The author presented these findings to

the organisation's SD strategic task force; all participating members agreed with the findings.

In Phase 3, two quantitative research activities seek to further explore and validate the abovementioned three core KS for SD barriers: lack of organisational slack, poor SD ICT systems and silo mentality. The first activity investigates the lack of organisational slack and silo mentality barriers; the second evaluates a SD intranet portal that was developed in response to the organisation's poor SD ICT systems.

4.3 PHASE 3A: QUANTITATIVE RESEARCH – SOCIAL NETWORK ANALYSIS

The aim of this quantitative research activity was to explore and validate the following two core KS for SD barriers identified in Phase 2: the lack of organisational slack and silo mentality. These were selected because of their prominence in Phase 2. Table 4.4 presents the four objectives that underpinned this aim, which are aligned with the core KS for SD barriers under investigation.

Table 4.4. Phase 3a research objectives aligned with two core barriers from Phase 2

Research objective	Lack of organisational slack	Silo mentality
Determine the level of intra-functional SD connectivity		✓
Determine the level of cross-boundary SD connectivity		✓
Determine the effectiveness of SD relationships	✓	
Identify key players	✓	✓

This research activity is published in the Journal of Cleaner Production, a copy of which is located in Appendix C and discusses the research process and findings in greater depth. However, a summary of the research undertaken and the key findings are summarised here.

4.3.1 Research Instrument

Social network analysis (SNA) was used to explore and validate the perceived lack of organisational slack and silo mentality. SNA can be used to examine social capital dimensions as it deals specifically with the structural and relational features of social capital, and can be modified to also measure the cognitive dimension (cf. Section 2.3.3). For example, it is often used as a primary and systematic means of mapping and assessing an entity's opportunities in terms of exposure to and control of knowledge and information (Haythornthwaite, 1996, Cross et al., 2001). Further,

whilst SNA has been applied in numerous fields, it is yet to be used for KS for SD within the civil engineering domain, as revealed by the systematic literature review; this presents an opportunity to deploy SNA in a new field.

The rationale for using SNA is that KS is inherently social, as defined earlier. SNA is related to the notion of SC (cf. 2.3.3) in that it can be used to reveal the structure of relationships between individuals, organisational members and external parties (e.g. clients, suppliers, competitors); i.e. it can be used to map social networks. Revealing a social network's structure allows identification of opportunities for improvement; e.g. pockets of intellectual capital, the need to socialise actors, how organizational learning may be enhanced (Liebowitz, 2005, Chan and Liebowitz, 2006). Thus, this approach can have significant benefits when attempting to evaluate and enhance KS.

Organisations are awash with social networks. These networks typically reflect how successful work is accomplished within the organisation as they can determine the effectiveness and efficiency of knowledge and information exchanges (Brown and Duguid, 2002). The two core KS barriers being investigated in this phase are symptoms of poor SC which SNA can directly address: organisational slack is necessary to develop and maintain the relational dimension of SC (Fliaster and Spiess, 2008, Wang et al., 2006); and social interaction amongst organisational units is reflected by the structural dimension of SC (Inkpen and Tsang, 2005, Kleinbaum and Tushman, 2008), and is considered particularly important in project-based settings (such as the case organisation) (Bresnen et al., 2005). SNA has been advocated and used to address such issues in other contexts (cf. Cross et al. 2002a, Fliaster and Spiess, 2008). As such, SNA was deemed an ideal, insightful and flexible approach which could quantitatively satisfy the research objectives presented in Table 4.4.

The principal purpose of this activity was to verify whether a lack of organisational slack and silo mentality are preventing KS for SD within the case organisation. To achieve this we asked the research questions presented in Table 4.5. These are explained in more detail in Appendix C.

Table 4.5. Research questions and objectives

Research question	Objectives
What is the level of intra functional SD connectivity?	• Determine network fragility using cut-points. • Analyse geodesic distances. • Identify clique substructures.
What is the level of cross-boundary SD connectivity?	• Identify cross-geographic relationships. • Identify cross-business group relationships.
How effective are the SD relationships according to: frequency of communication; awareness of knowledge and skills; access to contacts in a timely manner; and engagement in SD issues?	• Measure the relationship factors. • Identify strengths and weaknesses in measured factors. • Analyse correlation between measured factors.
Which key player roles are revealed in a SD context?	• Identify key players. • Determine level of dependency on non-population members.

Sampling

Specifying a boundary around the data to be collected and analysed is often a difficult task (Scott, 2000). The clearest boundaries were those of the organisation's hierarchy. As such, SGs were used to specify the population boundaries; this is known as a positional strategy (cf. Knoke and Yang, 2008). Through analysis of the organisation's annual staff survey, three diverse populations (i.e. SGs) were selected based on their perceived KS performance. Participation in the study was discussed and agree with the leaders of each SG to ensure full cooperation.

Internet-based questionnaire

As aforementioned, internet-based questionnaires were used for the quantitative research activities.

Four relationship factors were used to measure the effectiveness of SD knowledge exchanges between organisational members. These were based on Cross et al.'s (2001) *awareness*, *access*, *engagement* and *safety* factors, which were perceived to be important relationship measures in organisations. However, in a later publication Cross and Parker (2004) report *frequency of communication* to also be important when uncovering collaborative ties. As Phase 2's findings suggest that safety is not an issue (e.g. an open communication culture was frequently expressed) it was decided that safety would be substituted for frequency of communication to provide greater insight when addressing the issue of organisational slack.

The web questionnaire was bespoke to ensure respondents' ease of use. Potential survey error was reduced through testing and piloting. The deployed version consisted of four sections: an introduction page to provide an overview of the study, a confidentiality statement, and contact details; a page to gather information about the respondent (i.e. their name and email address); the contacts page where respondents provide the names, SG and perceived relationship status of their SD contacts; and, finally, a confirmation page that stated that the responses were collected successfully.

The questionnaire was available for four weeks, during which a follow-up 'reminder' email was sent to all non-respondents. An overall response rate of 76.8% was attained. Stork and Richards (1992) assert that SNA survey response rates should exceed 65%. The data was then downloaded and manipulated in Microsoft Excel so that it could be analysed in the UCINET (Borgatti et al., 2002) SNA software package.

Evaluation of research instrument

SNA increases construct validity by employing a systematic approach which directly addresses the objectives of this research phase. This is achieved by surveying entire populations rather than using sampling, thus ensuring a more holistic analysis of KS for SD relationships. Other aspects of the research instrument's design also support construct validity; e.g. the effectiveness of SD relationships being measured using four dimensions that were advocated by leading SNA practitioners and authors, and the use of actor attribute data that directly aligned with the cross-boundary analysis objectives. However, a lack of definitive key player SNA metrics may negatively affect construct validity; the author navigated this by using common metrics which make reference to their uses in identifying key players.

The manifold of cultural factors at play within social arenas (i.e. within the selected populations) means that each population is unique, thus this research instrument exhibits low external validity. However, the study of three distinct populations for the purpose of contrast and comparison aims to improve generalisability within the context of the case organisation.

Social networks are dynamic and temporal; it is likely that the networks under study are changing shape even as they're mapped. For example, organisational

members may join or leave a network, and relationships may fluctuate depending on personal and environmental conditions – all within a very short time frame. As such, the research instrument is expected to exhibit low reliability.

4.3.2 Key Findings

Figure 4.2 presents the sociograms of the studied SD networks. These show that SG2 is the most fragmented network, whereas SG1 and SG2 are more cohesive networks. Further, it is possible to identify potential weak spots in the networks; e.g. where non-population members provide act as gatekeepers between population members.

The collected network data was analysed against each research objective; details of the analysis is provided in Appendix C. This sub-section presents a brief overview of the findings from each of the research questions presented in Table 4.5, and the findings in relation to this sub-phase's aim: to explore and validate two of the core KS for SD barriers identified in Phase 2. It is noteworthy that whilst a lack of organisational slack and silo mentality were considered core KS for SD barriers, the findings presented here suggest that neither of these issues are as prevalent as initially believed.

Overview of findings

Level of intra-functional SD connectivity. Cut points were analysed to determine the fragility of each population. SG1, SG2 and SG3 have 14 (16.5%), 47 (18.2%) and 23 (26.4%) cut points respectively within their networks; SG1 is thus least fragile as it's not reliant on non-population members for SD connectivity. Geodesic paths were also calculated to determine the average path lengths between population members. The majority (i.e. more than 80%) of population members could be reached in up to four links. Finally, large numbers of small cohesive subgroups (weak cliques) were present within each network.

Level of cross-boundary SD connectivity. Figure 4.3 depicts the cross-geographic and -functional SD connectivity. The geographic sociograms suggest all populations have a strong UK focus; more than 75% of all actors resided within the UK. Further, in all networks the highest number of inter-region ties existed between UK North and UK South. The Middle East and North America regions were also prominent in SG1 and SG2. Interestingly (and understandably), the number of ties reduces in relation to distance; e.g. there are more intra-office connections in

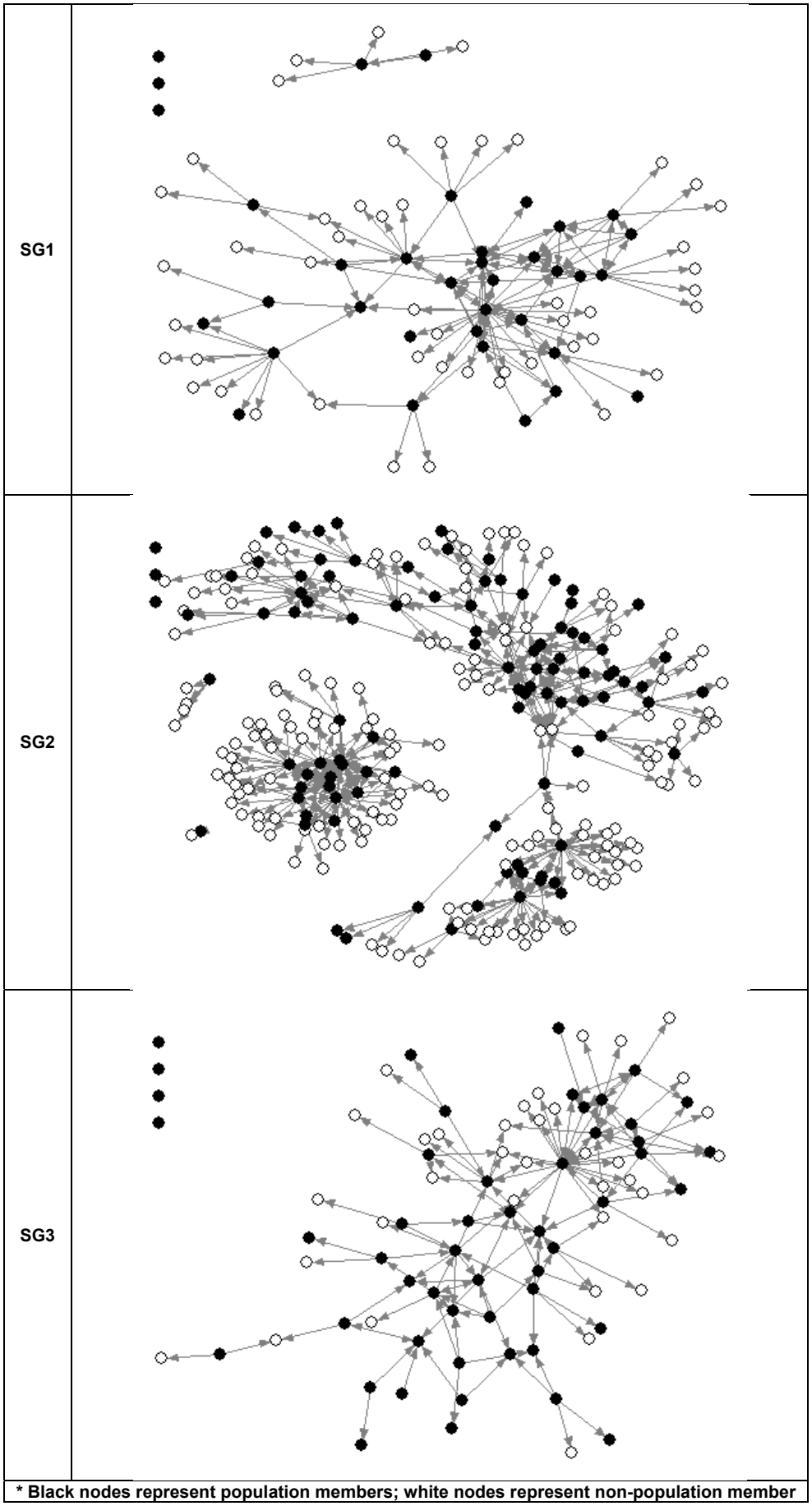


Figure 4.2. Sociograms of the collected SD networks

comparison with intra-region connections. The functional sociograms suggest that most connections were intra-population. However, it was found that populations were not bound to their business groups; on average more than one in four ties related to contacts that reside outside the population member's business group. This is important because although each skill group serves a predefined function it is important that they inter network because of SD's interdisciplinary nature.

Effectiveness of relationships. Awareness of contacts' knowledge and skills, access to contacts in a suitable time frame, and engagement with contacts when exchanging knowledge was deemed good in all populations (above 80% in the 'agree' or 'strongly agree' categories). The frequency of communication was infrequent in all populations, with most population members typically communicating with their SD contacts less than once a month. Correlation coefficients between the relationship factors were also calculated. This revealed that frequency of communication was the least influential factor measured; access and engagement were strongest correlated in all populations.

Key players. Central connectors, boundary spanners, information brokers and peripheral people were identified in all populations. All populations exhibited a high volume of peripheral people who seek SD knowledge; nearly half of these members had zero incoming ties (i.e. no other population members perceived them as a knowledgeable in SD matters). Roughly a similar proportion of boundary spanners and information brokers existed in each respective population. These members are vital to ensuring knowledge flows within and across the population's boundaries. Roughly one in five SG1 and SG2 population members are central connectors, yet SG3 only exhibited one central connector. SG2 and SG3 also had central connectors that reside outside their population boundary, placing additional emphasis on the need for good boundary spanners.

Lack of organisational slack

The majority of respondents in all populations indicated that the frequency of interaction with SD contacts was relatively low; roughly one in five contacts is contacted at least once a week. Such infrequent contact suggests that a large proportion of SD ties are weak. Weak ties have numerous benefits over strong ties, such as lower maintenance costs and knowledge seeking beyond immediate networks, but are likely to be less effective at exchanging complex SD tacit knowledge (Cross et al., 2002a, Granovetter, 1982, cf. Fliaster and Spiess, 2008).

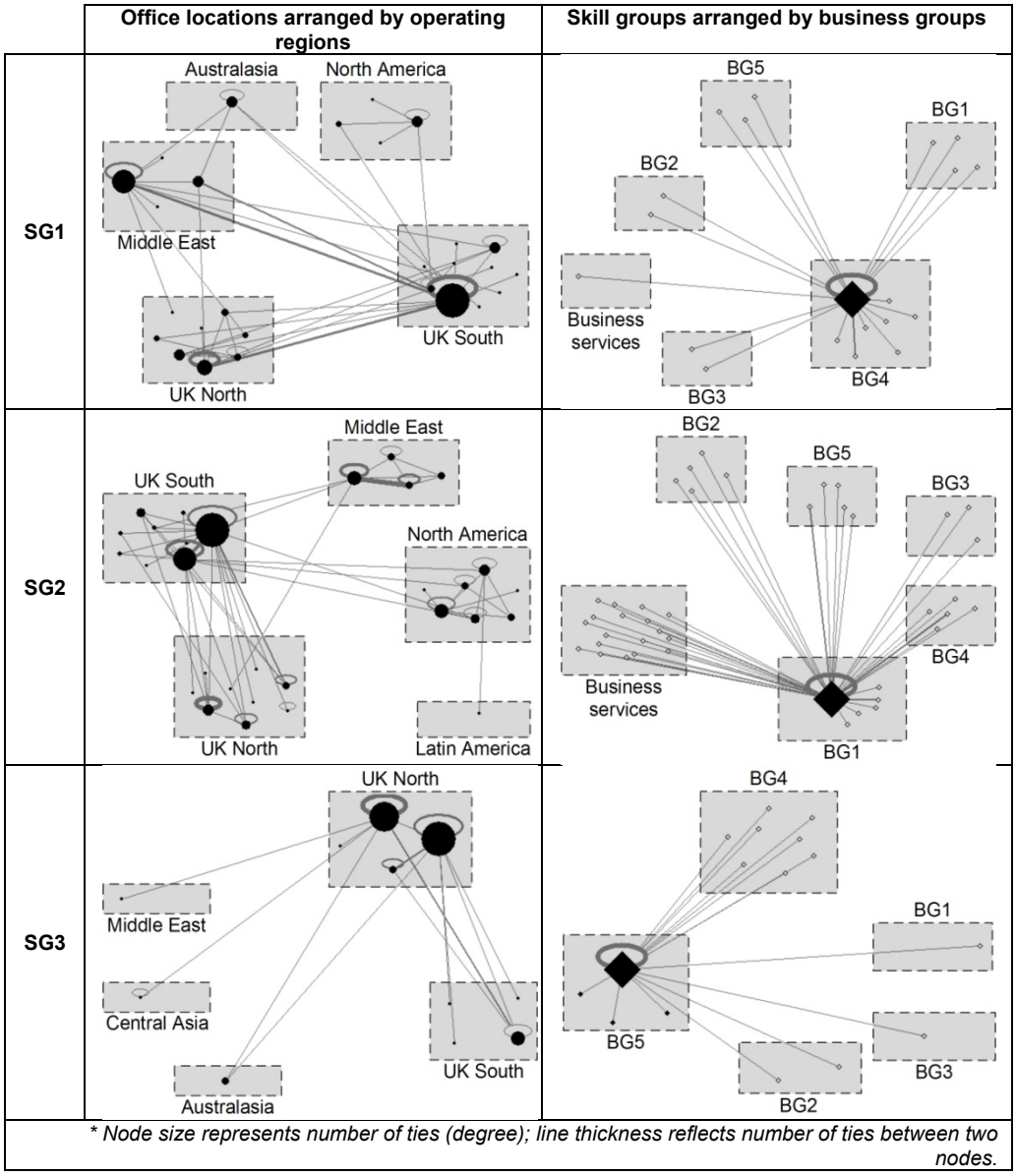


Figure 4.3. Whole network cross boundary sociograms

Although population respondents generally reported infrequent interaction with their SD contacts, it was found that this had relatively little impact on the respondents' awareness of, access to and engagement with them on SD matters. Thus, respondents felt they did not need to regularly interface with contacts in order to maintain good relationships that promote KS for SD, which is a KS enabler in itself.

It was found that powerful key players (e.g. central connectors, information brokers) within the SNs were often amenable to SD knowledge seeking requests, suggesting they were not impeding the SNs KS effectiveness by being overloaded with knowledge seeking requests (e.g. Cross et al., 2002b). To avoid KS disruption the following actions are proposed: key players are monitored to ensure they've

enough organisational slack to cope with KS requests; and more organisational members are encouraged to take on key player roles to improve their SN's resilience.

Silo mentality

The silo mentality barrier identified in Phase 2 is challenged in this sub-phase. Both cross- and intra-boundary relationships demonstrate that little evidence was found to support the presence of a silo mentality. Most KS ties were contained within the UK; this potentially highlights a need for greater international connectivity to support the integrated nature of SD. However, it is widely accepted that physical distance between actors can complicate matters when forging new relationships (Cummings, 2003) (e.g. time requirements, cost of face-to-face meetings), although these barriers often need to be overcome for new KS relationships to be successful (Davenport and Prusak, 2000, Hansen, 1999). Nonetheless, respondents' generally reported good awareness of contacts' SD knowledge and skills, which shows that they often exhibit a good understanding of cross-boundary SD capabilities.

Despite the existence of cross-boundary relationships respondents predominately cited fellow population members or non-population members who reside in the same office. A degree of cross-boundary disconnect was identified in all populations between those members who only have non-population SD contacts and those who only have intra-population SD contacts. This means that population members that do not exhibit cross-functional or -geographic SD relationships are reliant on other boundary spanning members to feed cross-boundary information and knowledge to them, thus decreasing their perception of residing in a silo.

4.3.3 Sub-Phase Summary

This sub-phase used quantitative SNA techniques to systematically map and assess organisational member's exposure to SD knowledge and information. Its aim was to validate two of the key findings from Phase 2. Using an internet-based questionnaire, three distinct SGs were surveyed about their intra-organisational SD contacts. Using SNA techniques little evidence was found to support the presence and prevalence of the KS for SD barriers identified in Phase 2.

Despite infrequent communication between network members, organisational slack was not deemed to be a barrier because of its low impact on awareness of, access to and engagement with intra organisational SD knowledge and skills. In

other words, maintaining SD relationships were found to require little energy. It is also noteworthy that key network members (e.g. central connectors) we seemingly unconstrained by time as they had sufficient time to engage with others on SD matters. A silo mentality was also not prevalent. All networks contain cross-boundary relationships. However, more could be done to improve the number of 'bridging' connections to support the complex integrated nature of SD and to ensure peripheral people are better engaged. These findings are particularly interesting as they contest two ubiquitous KS barriers, suggesting that they may be misconceptions of reality. Further, these barriers are widely understood to be common in civil engineering organisations because of their project-led and fragmented nature.

In-depth studies can provide rich insights into organisational idiosyncrasies. The research instrument developed here allowed the author to collect voluminous detailed structured data from members who were unaware of the study's overarching objectives. The data was then coupled with secondary data sources and analysed to provide a general understanding of the populations in relation to the overarching objectives. The author believes this approach was valuable in reducing potential measurement bias from directly questioning members about their organisational slack and cross-boundary KS (i.e. silo mentality); whilst it is postulated that most people would like more time and greater access to a diverse knowledge network, more does not necessarily equate to better.

SNA is a powerful analytical tool which enables researchers to make specific and more general observations regarding the structure, function (e.g. KS) and key players within social arenas. Such observations may spawn specific concerns; e.g., how the loss of a particular member may significantly impede KS across the SN and where strategic relationships may be cultivated to reduce this risk. However, the author believes that the success of this study lies with the original objectives that stemmed from Phase 2; without this clear purpose it would likely have proved difficult to draw and justify general conclusions from the wealth of data and available analytical techniques.

4.4 PHASE 3B: QUANTITATIVE RESEARCH – SD INTRANET PORTAL ANALYSIS

An intranet-based SD portal was developed in light of the poor SD ICT system findings from Phase 2 and organisational members (including two Phase 2 interview

participants) requesting a centralised SD resource tool. The aim of this quantitative research activity was to evaluate the SD portal's performance effectiveness and organisational members' intention to use it. Four objectives underpinned this aim:

- assess the usability, design and information quality of the SD portal;
- determine the social influence of the SD intranet portal;
- determine the perceived usefulness of the SD intranet portal; and
- determine users' behavioural intention of the SD intranet portal.

This research activity was peer-reviewed and published in an international conference proceedings, a copy of which is located in Appendix D. However, a summary of the research undertaken and the key findings are reiterated here.

4.4.1 Intranet – A Common Knowledge Sharing System

Intranets are a common KS platform in many organisations. Based on increasingly sophisticated internet technologies and concepts (e.g. servers, protocols, Web 2.0, discussion forums, RSS, and so on), intranets are private computer networks that provide a cost-effective, standardised approach to managing organisational knowledge (Scott, 1998). A principal use of intranets is as a strategic communication tool to support collaboration, interaction, and lowering of geographic and functional boundaries (Lee and Kim, 2009, Natarajan, 2008). Nonetheless, much research heeds caution to placing too much KS emphasis on information systems (cf. Section 2.3.10), despite the benefits which they can generate (cf. Chou, 1998). Consequently, many authors advocate the need for intranets to be regularly evaluated to ensure they're effectively supporting KS (e.g. Skok and Kalmanovitch, 2005, Van der Walt et al., 2004, Lai and Mahapatra, 1998).

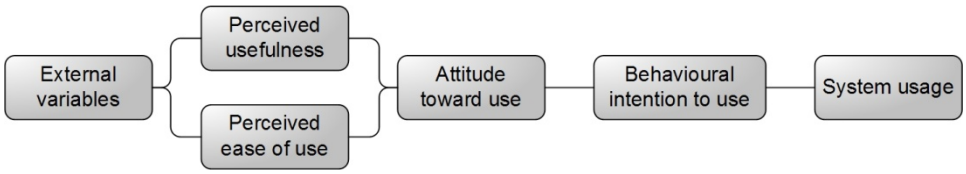
A brief description of the case organisation's intranet system is provided in Section 1.2.

4.4.2 A Brief Overview of Intranet Evaluation Approaches

The evaluation of quality and user acceptance of internet sites and applications has received much attention, yet by comparison intranets have received relatively little (Barnes and Vidgen, 2009). Nevertheless, a myriad of theoretical approaches have been used to evaluate intranet effectiveness, including: the technology acceptance model (TAM) (Davis, 1989, cf. Horton et al., 2001); the intranet acceptance model (IAM) (Barnes and Vidgen, 2009); the intranet evaluation model (Skok and

Kalmanovitch, 2005); the star model (Garavelli et al., 2004); end-user computing satisfaction (Doll and Torkzadeh, 1988); and the information systems success model (Delone and McLean, 2003). Approaches, such as these, generally evaluate perceived usefulness, ease of use, user satisfaction.

The TAM (Figure 4.4) is an extension of the theory of reasoned action (Fishbein and Ajzen, 1975) and is almost certainly the most widely cited approach to examining the uptake and usage of IT, with many other theoretical models stemming from some, if not all, of its constructs. Davis's (1989) seminal work asserts the following two independent constructs represent the beliefs that bring about acceptance: perceived usefulness – "the degree to which a person believes that using a particular system would enhance his or her job performance"; and perceived ease of use – "the degree to which a person believes that using a particular system would be free from effort". Venkatesh and Davis (2000) extended the TAM (referred to as TAM2) to explain perceived usefulness and usage intentions by incorporating "theoretical constructs spanning social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use)"; both additional constructs were found to significantly influence user acceptance.



Source: Lederer et al. (2000)

Figure 4.4. The technology acceptance model

However, neither TAM nor TAM2 assess the quality of technology – a vital aspect of any organisational KS system. For example, it is important for a KS system to provide: valid, comprehensible information; instil confidence in its users; and enable them to find the knowledge or information that they require. Barnes and Vidgen (2009) encompass these aspects in their IAM by adopting the usability, design and information quality dimensions extracted from their 'eQual' instrument (2002) with the specific intention of assessing the quality of an intranet; they found that although social influence and perceived usefulness had the most impact on intention to use, intranet quality was also a significant contributor.

4.4.3 Rationale

As Mohamed et al. (2009) point out: although some multinational organisations have improved the way they leverage knowledge through their information systems, "many still have their information and knowledge assets exist in disconnected repositories." This was the situation in the case organisation regarding SD knowledge and information. In response a SD portal was developed with the aim of a harnessing organisation-wide understanding, capabilities and experience in SD issues. A bottom-up initiative, the core development team consisted of five members: the case organisation's internally-focused sustainability leader who ensured the portal was aligned with organisational strategy; another EngD research engineer who specialises in sustainability assessment; the author who acted as a KM consultant and technical specialist; a member of the IT department who transformed the team's system requirements (i.e. structure and template) requirements into empty intranet pages; and a member of the communications team who ensured the portal's content and format adhered to the organisation's intranet publishing guidelines. As the project received little budget, the author's role shifted to respond to the project's needs. Thus, in addition to supporting KM aspects and technical understanding (e.g. how the existing system could be best utilised), he was also required to gather and structure SD knowledge and populate the pages using HTML and JavaScript code.

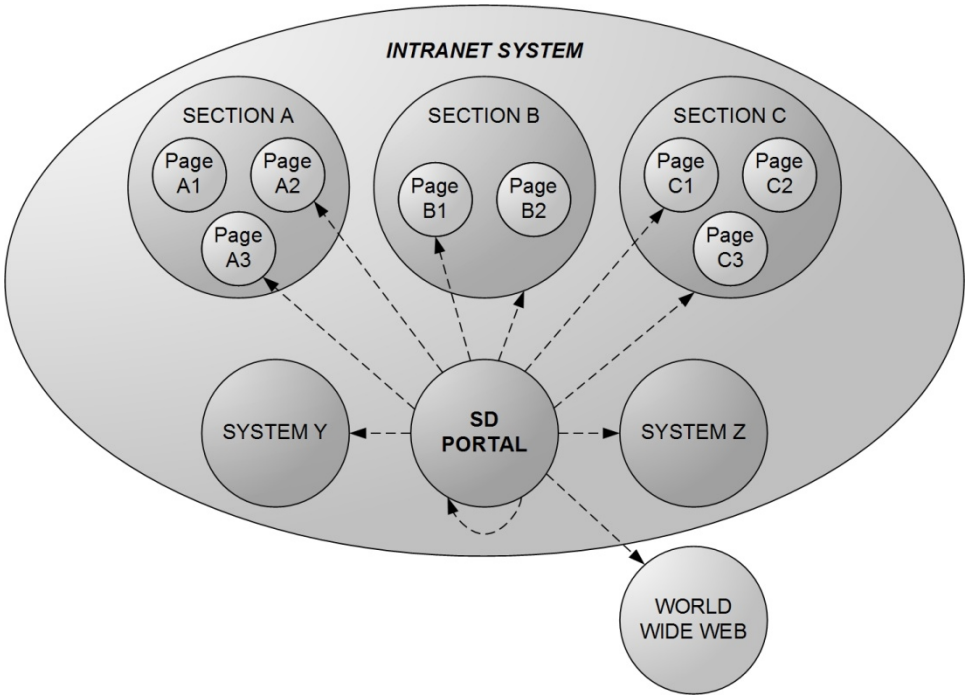


Figure 4.5. A simple abstract depiction of the SD portal providing centralised access to existing SD content

A fundamental purpose (and benefit) of the portal was to provide centralised access to a collection of organised hyperlinks to existing SD content and systems available locally or on the World Wide Web, accompanied by minimal contextual descriptions. The promotion of hyperlinks and demotion of 'rich content' was primarily to preserve context and avoid replication (cf. Figure 4.5). This approach allowed the development team to maintain a lightweight *modus operandi*, thus accommodating publishers and users perceived lack of time. To achieve this, consideration was paid to Desouza and Awazu's (2005) KMS maintenance activities: preservation of context; destruction of old knowledge; integration of knowledge; segmentation of knowledge.

Content on the SD portal was tailored around a holistic, integrated model of sustainability, developed by the team's sustainability assessment EngD research engineer. This model is presented on the portal's root homepage; elements within the model are hyperlinked to sub-pages. A common template was applied to each sub-page to segment the information, which comprised of: SGs that apply the given SD knowledge and information; news; guidance; legislation and regulations; tools; experience (e.g. case studies); community (e.g. working groups, organisational members with relevant skills); drop box (for feedback and new information); intranet discussion sites; and external links. Additionally, a set of overarching pages resided alongside this model to provide information about: the organisation's sustainability strategy; sustainable construction; affiliations with external SD bodies; SD activities calendar; who to contact regarding general SD matters; and so on. Specialists from around the organisation were invited to voluntarily take publishing ownership of pages that directly relate to their areas of expertise (e.g. energy efficiency, sustainable procurement). The development team initially worked with publishers to help them populate their respective pages.

In the first quarter of 2008 the SD portal was released on the organisation's intranet system. It was publicised through numerous channels, including: an intranet news item; short articles in the organisation's internal magazine and SD oriented newsletters; emails to SG leaders; and a permanent hyperlink to the portal on the intranet's homepage.

In the third quarter of 2009, the case organisation's board member responsible for SD requested the development of a second generation SD portal. This was predominately to enhance the usability, design and content so that the portal is

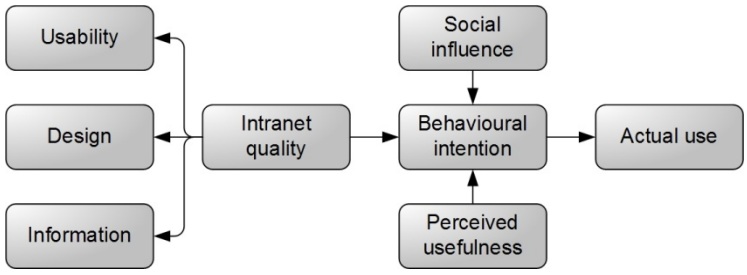
directly linked with the organisation's new sustainability strategy and key SD themes. As an action-research led project, this was the first development cycle (cf. Figure 3.3). Consequently, the author advocated the need to evaluate the quality and acceptance of the first generation SD portal. This was for two reasons: to assess how the SD portal could be improved; and to set a benchmark for the evaluation of the second generation SD portal, which the author would conduct for the purpose of comparison.

4.4.4 Research Instrument

This subsection presents the design and deployment of the research instrument used to address the research objectives of this sub-phase.

The adopted evaluation model

The real context of this study meant that the author required a validated model; if a new theoretical model failed to deliver positive validity and reliability measures, it is likely that the data would not generate the same value as a tested model. Whilst the models cited in Section 4.4.2 have been validated, Barnes and Vidgen's (2009) IAM (Figure 4.6) was the only model reviewed that was specifically designed for intranet evaluation and included the intranet's quality as a (second order) construct for user acceptance. As such, the IAM would not only provide a benchmark for the next generation SD portal, but a more holistic assessment of which aspects could generate the greatest overall improvement. Thus, the IAM was adopted for this sub-phase.



Source: Barnes and Vidgen (2009)

Figure 4.6. Intranet acceptance model

Analysing the collected data

The IAM uses partial least squares (PLS) to analyse the collected data, and was therefore adopted in this sub-phase. Over the years the PLS method has become an increasingly popular method for soft modelling, especially in exploratory information systems research (Marcoulides et al., 2009).

PLS is used to statistically analyse causal relationships among latent constructs (known also as latent variables); i.e. it is used for constructing predictive models. Latent constructs are research abstractions that cannot be measured directly; e.g. beliefs and perceptions (Gefen and Straub, 2005). Consequently, they must be measured indirectly using measurement items (i.e. observed or manifested variables) in a research instrument.

PLS embraces two distinct modelling approaches: regression models (an extension of the multiple linear regression model, used for predicting a set of dependents from a set of independents) and path models (akin to structural equation modelling (SEM)) (Garson, 2011). It is the latter approach which is used for determining the relationship between latent constructs. Thus, path modelling was adopted for the IAM analysis using Smart-PLS 2.0 software (Ringle et al., 2005). Henseler et al. (2009) summarise the characteristics of PLS path modelling as:

- PLS delivers latent variable scores, i.e. proxies of the constructs, which are measured by one or several indicators (manifest variables);
- PLS path modelling avoids small sample size problems and can therefore be applied in some situations when other methods cannot;
- PLS path modelling can estimate very complex models with many latent and manifest variables;
- PLS path modelling has less stringent assumptions about the distribution of variables and error terms; and
- PLS can handle both reflective and formative measurement models.

PLS path models comprise of two sets of linear equations: the inner model (known also as the structural model) is concerned with the relationships between the latent constructs; and the outer model (known also as the measurement model) is concerned with the hypothesised relationships between the latent constructs and their respective measurement items. Parkkila et al. (2011) succinctly describe the two stages of the PLS path modelling algorithm (cf. Tenenhaus et al., 2005 for detailed algorithm):

> "The first stage only consists of an iterative procedure of OLS [ordinary least squares] regressions, linear operations and square root extractions. Using the inner and outer models the PLS path modelling algorithm calculates the proxy values to the latent variables as the weighted sums of their indicators. This iterative procedure continues until the weights converge. The second stage of the PLS path

> modelling algorithm is a non-iterative estimation of the inner and outer model coefficients." (Parkkila et al., 2011)

Sampling

As the first generation SD portal exhibited a strong UK focus, it was agreed with the case organisation that the study's target population would comprise of UK-based organisational members. Furthermore, as the SD portal was designed to support project-oriented organisational members in SD matters it was also agreed that the target population would be exempt of support staff.

As the target population was moderately large a cluster sampling strategy was employed to improve coverage. Cluster sampling is based on the target population being divided into groups, with elements within each group being randomly selected (cf. Kumar, 2005, Dixon et al., 1987). Therefore, elements within the target population were clustered according to their SG. As the number of organisational members within each SG varied dramatically, the percentage of elements to be sampled from each cluster was calculated according to the total number of elements within the target population; all decimal results were rounded to the nearest whole number.

Determining a suitable sample size is important, especially when applying statistical analysis. PLS is often said to be able to handle small to medium sized samples (Haenlein and Kaplan, 2004), yet Chin et al. (2003) suggest this isn't necessarily true. According to Chin et al.'s (2003) PLS Monte Carlo Simulation findings, the research model used in this sub-phase requires a sample size of 150 "to balance the trade-offs for detection and accurate estimate". As such, 250 organisational members (more than 8% of the target population) were randomly sampled from the target population's clusters (as implied above, the number of elements sampled from each cluster related to the cluster's size). This allowed for a response rate of at least 60% – thus providing the required sample of 150 to apply the PLS analysis technique.

Internet-based questionnaire

The author adopted the validated questionnaire designed by Barnes and Vidgen (2009). The questionnaire was internet-based, developed and deployed using an online survey service. As in Sub-Phase 3a, the author applied the practical guidance for the administration of internet-based questionnaires (cf. Section 3.4.3).

Table 4.6. IAM questionnaire instrument

Latent constructs	Measurement items
Intranet quality: Usability	• Learning to operate the portal is easy for me • My interaction with the portal is clear and understandable • I find the portal easy to navigate • In general, I find the portal easy to use
Intranet quality: Design	• The portal has an attractive appearance • The design of the portal is appropriate for this type of site • The portal conveys a sense of competency • The portal creates a positive experience for me
Intranet quality: Information	• The portal provides accurate information • The portal provides timely information • The portal provides complete information • The portal provides easy to understand information
Social influence	• People who influence my behaviour think that I should use the portal • People who are important to me think I should use the portal • The senior management have been helpful in the use of the portal • In general, the organization has supported the use of the portal
Perceived usefulness	• Using the portal enables me to accomplish tasks more quickly • Using the portal increases my productivity • Overall, I find the portal useful in my job
Behavioural intention	• I intend to use the portal on a regular basis • I predict I will continue to use the portal on a regular basis • I plan to use the portal on a regular basis
Actual use	• In an average week, how much time would you say you spend connected to the portal (for any kind of service and counting all the possible sessions over the week)?

Adapted from: Barnes and Vidgen (2009)

The questionnaire comprised of five sections: an introduction page; a respondent information page; an IAM measurement items page; a comments feedback page; and a completion confirmation page. The introduction page presented respondents with the purpose of the study, a confidentiality statement, and the author's contact details in case of any issues or concerns. Next, respondents were requested to input details about themselves (e.g. email address, age, years experience in the case organisation) and to indicate which areas of the portal they use most. Dynamic routing was used at this stage; if a respondent was either unaware of the SD portal or never use it, they would be redirected to the comments feedback page, thus skipping the IAM measurement items page to avoid confusion or collection of invalid data. The IAM measurement items page was organised according to the constructs and indicators presented in Table 4.6; respondents indicated their agreement with each statement using a five-point Likert-type scale (strongly agree to strong disagree) or by selecting the additional 'not applicable' option. The penultimate section encouraged respondents to provide comments or

suggestions regarding how the SD portal's engagement and functionality could be improved.

To encourage a response rate of at least 60% two email rounds were conducted; the first invited the sampled members to participate in the study, the second prompted non-respondents to participate. All questionnaire correspondence was sent by the development team's sustainability leader who is well recognised within the case organisation.

A total of 158 responses were received, representing a respectable response rate of 63.2%. Responses from the questionnaire were downloaded in a Microsoft Excel format for analysis. Unfortunately only 36 responses were usable as most respondents stated that they're unaware of the portal or simply do not use it. This meant that there was not enough data to apply the PLS path modelling technique as intended.

Evaluation of research instrument

In PLS the outer model's construct validity must be examined to indicate the goodness of fit; i.e. how well the measurement items relate to the latent constructs (cf. Gefen and Straub, 2005). This comprises of two factorial validities: convergent and discriminant. T-statistics are used to prove convergent validity by calculating the loadings to determine whether the results are greater than 0.50. Discriminant validity is proved by the average variance extracted (AVE), calculated as the square root of the average communality; according to Fornell and Larcker (1981), the test for discriminant validity is to compare the AVE statistics with the correlations between the latent constructs. These construct validity tests are embedded in the Smart-PLS software package.

Internal validity is relevant in this sub-phase as the IAM analysis is concerned with causality. This was assessed by examining the magnitude, hypothesised sign and t-statistic significance of the path coefficients. These internal validity tests are embedded in the Smart-PLS software package.

The research conducted within this thesis is concentrated in one case organisation, thus limiting the external validity of the findings. However, should the IAM implementation generate results that correlate with Barnes and Vidgen's (2009), it would reinforce the model in a different setting, thus improving its external validity.

Reliability differs from convergent validity in that it only considers measurement items within, not across, constructs. Whilst there are many approaches to testing reliability (e.g. Cronbach's alpha, test-retest reliability), Barnes and Vidgen (2009) applied a composite reliability test. An adequate model for exploratory purposes should produce composite reliabilities greater than 0.60 (Bagozzi and Yi, 1988).

4.4.5 Findings

This sub-section presents the key findings from the collected data. Although the low number of usable responses meant it was not possible to apply the PLS path modelling technique, insight into the SD portal's success was evaluated by analysing the respondents' characteristics, IAM measurement items, and comments.

Respondent characteristics

Table 4.7 presents the respondents' characteristics in relation to the population which they represent. Generally speaking, respondents' characteristics correlate well with the population's characteristics; although a small number of notable deviations were present (e.g. 1 to 3 years experience in case organisation). The majority of respondents were between 26 and 35 years of age, with 44.4% of usable responses falling into this category. Furthermore, whilst the majority respondents have worked for the case organisation between one to three years, the majority of usable responses were provided by those who have worked there for more than ten years.

Table 4.7. Population and respondent characteristics

Characteristic	Scales	Population	All responses	Usable responses*
Gender	Female	20.3%	20.9%	30.6%
	Male	79.7%	79.1%	69.4%
Age	Under 26	11.9%	12.7%	5.6%
	26 to 35	37.1%	38.6%	44.4%
	36 to 45	23.8%	23.4%	22.2%
	46 to 55	16.1%	12.0%	11.1%
	Over 55	11.2%	13.3%	16.7%
Experience in case organisation	Less than 6 months	1.5%	5.1%	5.6%
	6 months to a year	9.6%	9.5%	11.1%
	1 to 3 years	34.7%	29.1%	19.4%
	3 to 5 years	17.0%	20.9%	16.7%
	5 to 10 years	19.4%	19.0%	19.4%
	More than 10 years	17.8%	16.5%	27.8%

** Usable responses are those that completed the IAM questions (Table 4.6) and represent 22.8% of all responses*

The SD portal's usage response data are presented in Table 4.8. It is evident that most respondents have never heard of the SD portal or do not generally use it. Those respondents that do connect to the SD portal typically use it for less than fifteen minutes a week. The most popular sections of the SD portal were the SD model presented on the portal's homepage and the 'who to contact' section; the 'not applicable' responses reflect those respondents who use the SD portal on demand (i.e. seeking specific SD knowledge or information), thus do not repeatedly use one particular section[2].

Table 4.8. Respondents' SD portal usage

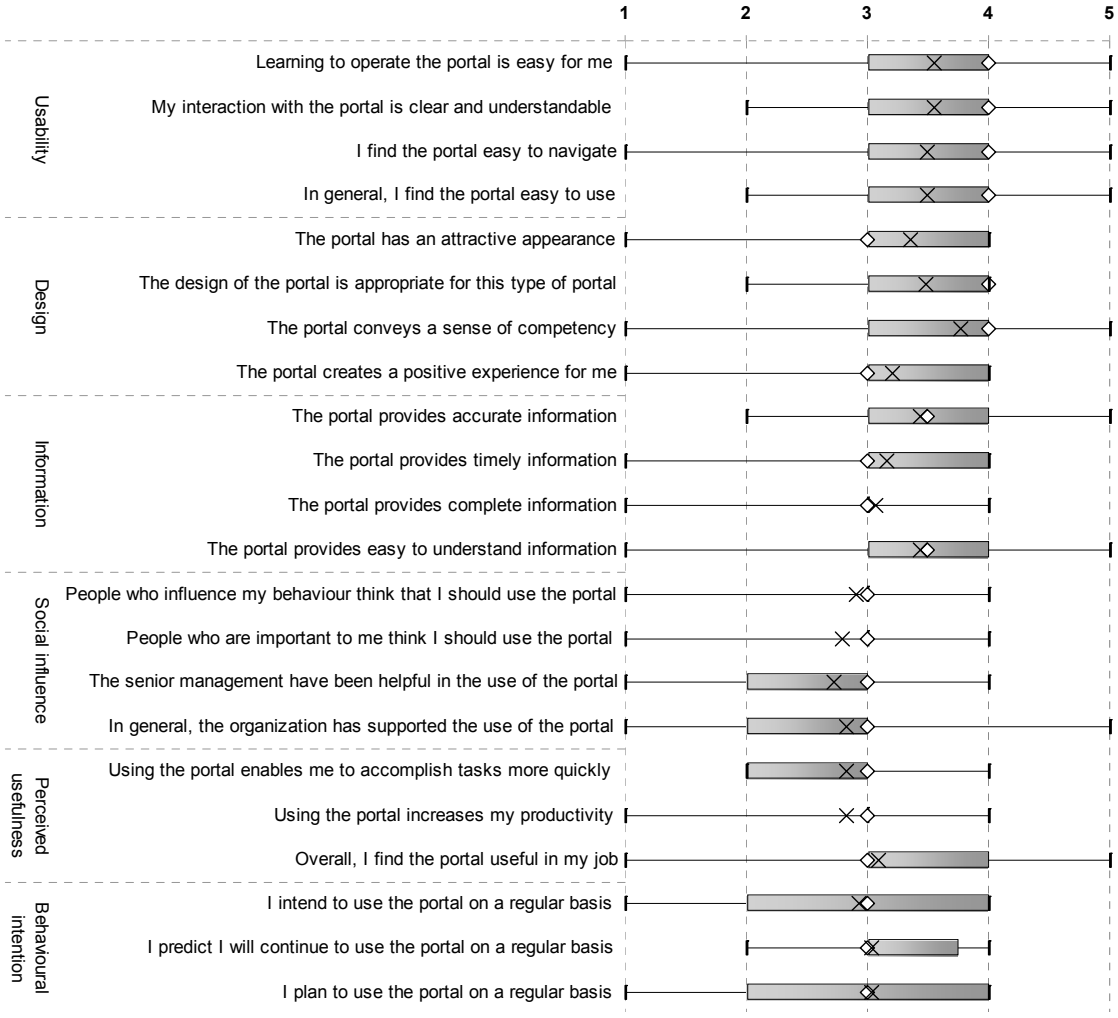
Question	Scales	Percentage of responses
In an average week, how much time would you say you spend connected to the SD portal (for any kind of service and counting all the possible sessions over the week)?	Have never heard of it	38.6%
	Don't generally use it	46.2%
	Less than 15 minutes	12.0%
	Between 15 minutes and 30 minutes	1.3%
	Between 30 minutes and 1 hour	1.3%
	Between 1 and 2 hours	0.6%
	Between 2 and 4 hours	0.0%
	Between 4 and 10 hours	0.0%
	More than 10 hours	0.0%
Which section of the SD portal do you use the most?	Calendar	13.9%
	Community	0.0%
	Consultations	5.6%
	Cross cutting themes, capability and case studies	11.1%
	Discussion forums	2.8%
	Help and navigation	5.6%
	Policy and initiatives	2.8%
	The SD model	25.0%
	Who to contact	22.2%
	Not applicable	11.1%

IAM measurement items' responses

A boxplot of the quantitative IAM measurement items from the usable responses is presented in Figure 4.7; this provides the minimum, first quartile, mean, median, third quartile and maximum metrics, thus showing the distribution of agreement for each measurement item. Intranet quality was the most favoured aspect of the SD portal; most respondents found the portal usable, being appropriately designed and conveying a sense of competency. However, some intranet quality aspects require attention; in particular the portal's completeness of information, which generally scored lowest out of all the intranet quality related measurement items. Respondents generally sat on the fence concerning the portal's usefulness; the responses were skewed towards the portal not accelerating task completion, despite it more frequently being perceived as useful in the respondents' job. The intention to use the portal in the future received mixed responses, generally siding on

[2] This was unearthed by the author following a series of informal follow-up conversations with the four relevant respondents.

'disagree'; although, respondents' predict that they will continue to regularly use the portal was marginally more positive. Finally, social influence was the weakest construct of all, implying that users of the portal do so autonomously.



1 = strong disagreement, 5 = strong agreement; ◇ = median; × = mean

Figure 4.7. Boxplot of IAM measurement items

The correlation coefficients between the usable responses measurement items are provided in Appendix F; the mean and median coefficient is 0.42, representing generally weak correlations between the items. Figure 4.8 presents the measurement items that exhibit a correlation coefficient greater or equal to 0.70. A number of inferences can be made from these stronger relationships:

- the behavioural intention measurement items are strongly correlated;
- the usability measurement items are strongly correlated;

- respondents who find the portal useful in their job expect to use it on a regular basis;
- creating a positive user experience positively influences predicted future use; and
- the ease of learning to operate the portal is related to the ease of understanding its content.

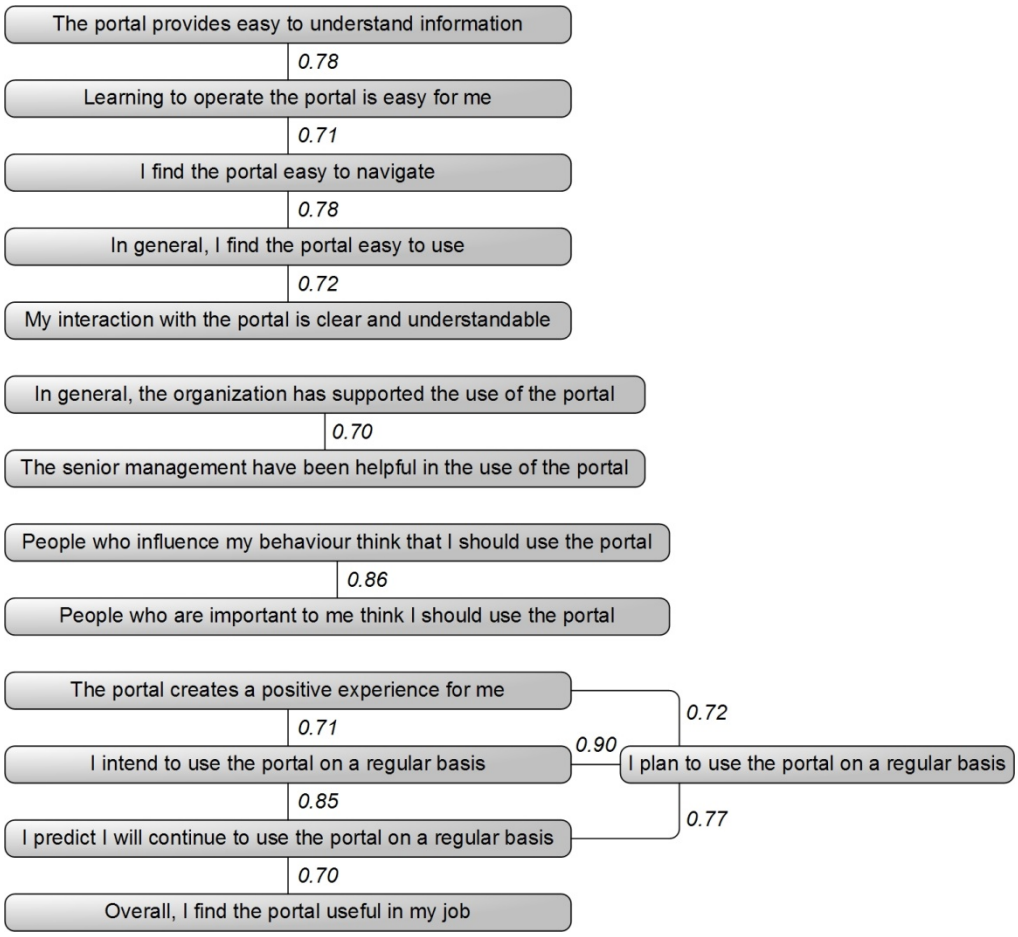


Figure 4.8. Network map illustrating measurement items with correlation coefficient ≥0.70

Comments analysis

Fifty-four open comments were collected from respondents, eight (14.8%) of which were provided by respondents who completed the IAM measurement items. Figure 4.9 presents the distribution of the eleven themes that were grounded in the comments.

Although a number of positive comments were received regarding the SD portal as a technical artefact (e.g. “The site is useful and I mostly use it to keep me informed of issues when visiting clients”), most were concerned with shortfalls or

potential improvements. The most common comment theme related to the poor publicity of the SD portal, with the questionnaire inadvertently raising awareness of its existence; for example:

- "This must have gone completely under my radar – sorry. Perhaps some advertising on [the intranet]?"
- "Sorry I have not looked at the site possibly because I have not been involved in a project which I think may be of suitable – I will look at it now."
- "No-one I sit near has heard of it so obviously more publicity is needed!"
- "A little more publicity might be useful, I haven't used this function and don't know how it might help me with my work."

The above latter comment relates to the theme that some respondents did not feel the SD portal was relevant to their job; e.g. "My non-use of the [SD portal] is no reflection on the service it offers, merely that I do not use it as part of my work" and "[I] Struggle to see its relevance to the work I do". However, this maybe a result of the SD portal's unclear purpose and aims; comments regarding this themed issue include:

- "There is a gap between needing and/or knowing we need to use the information on the [SD portal] site to fulfil day to day work tasks."
- "I haven't yet used the [SD portal], and I am unsure under what circumstances I should."
- "First of all I think this [SD portal] needs to be introduced to people in a bit more detail, such as what is this for, what can this do and how will this make a different to our day to day work."

Respondents also suggested that training was required in order to understand how to use the portal and how it's related to existing work processes; e.g. "I have used it to increase sustainability offering in bids but struggle to see how the [SD model] could be applied to my work; a WebEx talk on its use would be useful". This comment, amongst others, suggests that the SD portal's homepage design may be discouraging users; e.g. "First impressions are important so the 'front' page should be welcoming. The [SD model] is impressive but a little overwhelming at first glance".

Finally, one non-IAM respondent stated the prevailing need for a budget code to engage with the portal: "People won't be inclined to visit these tools or take part in

initiatives unless there's a job code. With every staff member facing the prospect of losing their job at the moment, utilisation is a key metric and I'm guessing the [SD portal] will be pretty low on their list of priorities; another challenge for you to overcome." Evidently, the lack of organisational slack may be restricting members from seeking SD knowledge and information from on-demand electronic resources, which may prove useful in their job (as implied by the usable responses (cf. Figure 4.7)). A potential means of overcoming this challenge may be to 'push' relevant SD knowledge and information at users, in addition to the existing 'pull' system. The benefits of push systems has been recognised in SD-related fields (e.g. Isenmann and Lenz, 2001), and was advocated by a number of respondents; for example:

- "My apologies if this is already done, but prompts or email alerts when something new arises on the [SD portal] would be useful to stimulate use."
- "Regular email notifications of updates and potentially useful information."

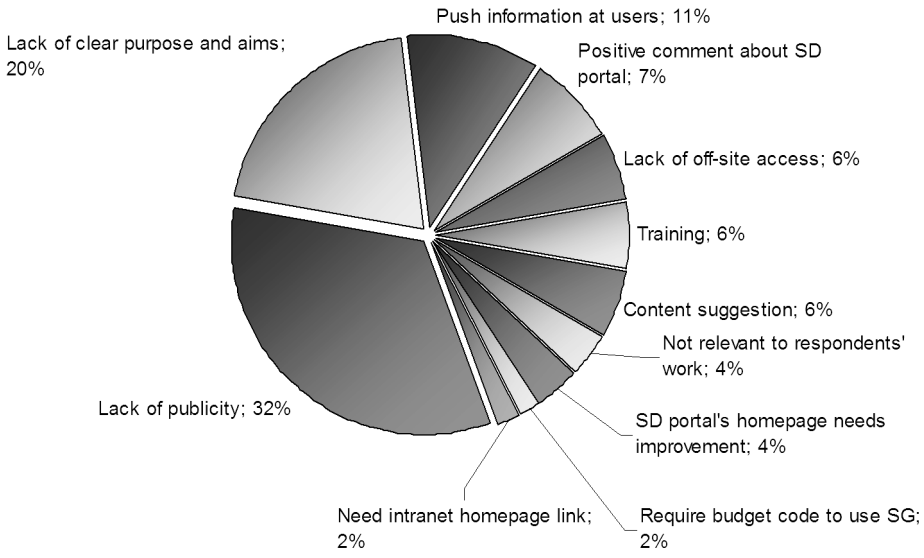


Figure 4.9. Respondents' comment themes

4.4.6 Discussion

It is recognised that portals can be powerful KS tools but are not easy to implement (Benbya et al., 2004). Civil engineering related disciplines are recognised for their strong social component, which has led to a conservative, even sceptical, view of technology (Ruikar et al., 2007, Esmi and Ennals, 2009). However, more recently efforts have been made to capitalise on the benefits of technology (Dave and Koskela, 2009), thus it is ever more important that the case organisation follows suit. Unfortunately, the limited findings clearly suggest that the SD portal is not widely recognised or used.

A large proportion of respondents are not aware of the SD portal. The comments analysis suggests a lack of publicity has prevented organisational members using the portal, with the IAM questionnaire acting as a publicity tool (Barnes and Vidgen, 2009). This barrier is not uncommon; in a study of eight main players in the corporate market, Benbya et al. (2004) found many cases where organisational members were unaware of a technology's existence. Hall (2001) proposes the promotion of such technology is a straightforward process, comprising of email shots, cross-linking and good indexing of resources. Such activities should be consigned by senior management as part of an implementation strategy. The poor awareness of the SD portal's existence resonates with the IAM's social influence which was considered the weakest of all measured constructs. The results show that senior management and overall organisational support are especially poor. As established earlier, leadership is a key component of any KS initiative. As Masrek et al. (2008) found, intranet systems equally require such backing from senior management, a finding also supported by Barnes and Vidgen (2009). Curry and Stancich (2000) assert that whilst top-down commitment and resourcing is fundamental, bottom-up buy-in from members across the organisation is also necessary. Thus a level of autonomy must be provided that allows organisational members to pursue SD knowledge rather than habitually recycling conventional SD knowledge (Hall, 2001). The findings suggest that existing users may already be acting autonomously, yet others remain constrained by issues such as a lack of organisational slack.

Those organisational members that are aware of the SD portal do not often use it. The IAM perceived usefulness construct and comments analysis suggest that this is a consequence of users not believing the portal is not especially useful. Much research states it is important that technology is aligned with user needs and organisational context for successful uptake. This corresponds with the finding that the portal's usefulness in organisational members' job is correlated with their future use; a finding that resonates with Lee and Kim (2009). As Benbya et al. (2004) assert, "Frequently, technology is not designed for the work people actually do but rather for the work technologies think they should do". In a review of KS using intranets, Natarajan (2008) concludes that such technologies should also be consistent with organisational goals. The comments analysis suggests that the portal fails to achieve this through a lack of clear purpose and aims. Therefore, to improve the uptake of the portal a contextual enquiry (Daniel et al., 2003) is necessary to

align the portal with the case organisation's culture and work practices (Payne and Sheehan, 2004).

Research implies that the easier the portal is to use, the more likely organisational members are to use it (Hew and Hara, 2007). This is encouraging as the portal's usability and design are its highest rated measured constructs. However, the comments analysis shows that some respondents feel training may encourage user participation. Training is often considered a fundamental aspect of technology adoption (Ardichvili, 2008, Goh, 2002); simply providing technology is not enough, users need to possess the skills necessary to efficiently and effectively interface with the portal (Gluch and Raisanen, 2009). Providing this form of support will encourage usability and accessibility (Masrek et al., 2008, Lee and Kim, 2009). Furthermore, this should reinforce a KS culture where organisational members actively maintain the SD portal's content to prevent its deterioration (Huysman and de Wit, 2004).

A push KS approach was also advocated by respondents. This would disseminate information to organisational members based on their work requirements or personal profile. Correctly managed, it can provide a highly valuable service by raising awareness of extant knowledge that can help organisational members' better achieve their goals. It is especially useful in organisations that are constrained by a lack of organisational slack, such as the case organisation, as it automatically seeks knowledge on your behalf (Benbya et al., 2004). However, a drawback to such systems is that without good integration the system can broadcast large volumes of information which exhibit little relevance or timeliness to recipients; i.e. the important stuff can be drowned out by superfluous noise (Coakes, 2006). Nonetheless, such a service may help to heighten organisational members awareness of the SD portal and its latest content. In response to this the core development team met with the case organisation's IT manager to discuss implementation options in relation to an information push system. This meeting revealed that although it is possible to purchase off-the-shelf plug-ins (e.g. an information push capability) for the existing intranet platform, it can only be achieved at a cost that was outside of the SD portal's budget (predominantly due to risk assessments and formal testing).

Overall this discussion agrees that the SD portal can enable and catalyse KS for SD (e.g. aid in decision making, organisational learning, and strengthen social

networks). For this goal to be realised it is vital the socio-cultural and organisational factors that underpin all KS initiatives are not ignored (Rezgui et al., 2010). This is principally because whilst providing access to organised SD knowledge and information resources is the goal of the SD portal, adopting, adapting and applying its content is often a social affair (Lin, 2007). However, the above findings and discussion also call into question the suitability of the portal for managing SD knowledge. As aforementioned, SD knowledge is rapidly evolving, thus requiring a technological platform which can cope with high-levels of interactivity (e.g. decentralised, Web 2.0). The rigid, centralised intranet platform potentially lacks the capability to keep abreast of constantly changing SD knowledge. In response, organisational members depend on more personal approaches to share SD knowledge, and will probably continue to do so until the organisation introduces improved KM technologies.

A number of limitations need to be considered in relation to this research. First, the research is conducted within a single organisation, thus limiting the external validity of the findings. Second, the sample was drawn from a UK only population, thus further work is required to determine whether overseas organisational members exhibit similar perceptions. Finally, the IAM measurement items received a limited usable response, thus statistical inference is limited.

4.4.7 Sub-Phase Summary

This sub-phase set out to evaluate the quality and user acceptance of a SD portal – a dedicated SD system located on the organisation's intranet which was developed in response to the poor SD ICT systems core barrier identified in Phase 2. A number of existing validated intranet evaluation models were reviewed; Barnes and Vidgen's (2009) IAM was selected predominately as its design was tailored specifically for intranet site evaluation, with it extending the TAM to encapsulate a quality assessment. Using an internet-based questionnaire, 250 organisational members were surveyed about their interaction with and perceptions of the portal.

Sadly, it was not possible to implement the intended statistical PLS technique using the collected data. Although a respective response rate was achieved, a large proportion of responses were unusable. This was for two reasons: respondents lacked awareness of the portal or did not use the portal.

A discussion on the collected data suggests that greater alignment with user needs and senior management support is needed for the SD portal to deliver greater benefit. It is, however, noteworthy that despite a call for an online centralised SD resource and the promotion of the resource through numerous communication channels, the portal has experienced poor recognition and engagement. This shows that the proverb 'if you build it they will come' is not applicable in this context, even though organisational members exhibit a desire for such systems. Consequently, poor SD ICT systems is not a barrier in itself; socio-cultural factors must also be considered and managed accordingly to ensure such systems are used.

The findings from this sub-phase were communicated to the portal's core development team and were frequently revisited during the development of the second generation portal. It was the author's intention to reiterate this evaluative process three months after the release of the second generation portal to assess the degree of improvement in terms of the portal's quality and user acceptance. Unfortunately, as a consequence of the economic downturn the SD portal's resources (e.g. budgets and team members' time) were significantly reduced. This ultimately led to the second generation portal not being fully developed or released. Consequently, the author was unable to conduct a second evaluation during the second action research cycle.

4.5 SUMMARY

This chapter began by reiterating that the overarching mixed-method research design required the execution of both qualitative and quantitative research with the use of primary and secondary data sources. It also reinforced that the design was inherently exploratory with the findings from each research phase influencing or informing the development of subsequent phases.

The approach to the background and systematic literature reviews was then outlined. The outcome of these research activities is presented in Chapter 2; a full account of the systematic literature review is provided in Appendix A. These outputs suggested that KS can positively affect SD performance in civil engineering organisations, and that relatively little research has been conducted in this area.

The qualitative research undertaken was then summarised; a full account of this phase is provided in Appendix B. A series of interviews were conducted to explore the enablers and barriers to of KS for SD within the case organisation and potential

improvement opportunities. Using an interpretive QDA process, a number of KS for SD enablers were identified, including: an open communication culture; KM time code allocation; and motivated organisational members who recognise the value of and need for KS for SD. However, three core barriers were recognised as permeating the interview data, composed of: lack of organisational slack; silo mentality; and poor SD ICT systems. These findings were presented to the case organisation's SD task force who agreed that these core barriers fundamentally constrain KS for SD. In accordance with the research design (Figure 3.4), these barriers were further explored during the quantitative research activities.

A summary was then presented of the systematic SNA approach used to explore the case organisation's perceived lack of organisational slack and silo mentality in relation to KS for SD; a full account of this phase is provided in Appendix C. Using an internet-based questionnaire, three SG populations were asked to volunteer details about their intra-organisational SD contacts. Analysis of this collected data suggests that neither the lack of organisational slack nor silo mentality is as prevalent as initially believed. Although organisational members reported generally infrequent contact with SD peers, it was not necessarily a barrier; frequency of contact had little bearing on members' awareness of, access to and engagement with their SD peers, for which these relationship factor were positive overall. Whilst the majority of ties connect co-located peers, high numbers of non-populations members (i.e. cross-functional) were referenced the studied populations. Additionally, key players within each population were identified; the analysis suggests that these members are cooperative but should be monitored to ensure they are provided with adequate resource (e.g. time) so they can continue to support KS for SD.

The evaluation of a SD intranet portal aimed to address the perceived poor SD ICT systems. A validated intranet acceptance model was adopted to evaluate the first generation portal, using an internet-based questionnaire to collect data. Unfortunately, whilst an acceptable response rate was achieved, the majority of responses were unusable; this meant the application of the desired PLS approach was not possible. Analysis of the responses suggests the SD portal's shortcomings include: a lack of awareness of the portal; and respondents not using the portal because they do not perceive the SD portal as a useful resource in their job. Based on the responses that were received it was found that the SD portal's quality constructs were good and the strongest measured. Conversely, the other constructs

were unexceptional, with social influence being the weakest measured construct. These findings were reported to the SD portal's core development team to support the development of a second generation portal which failed to be fully developed and launched due to budget cuts.

CHAPTER 5
DISCUSSION AND RECOMMENDATIONS

The purpose of this penultimate chapter is to review the research undertaken in relation to the overarching aim and objectives outlined in Chapter 1. To begin, the relationships between the primary data research phases are discussed. A set of recommendations are then presented in accordance with the discussed findings and conjectures. Finally, a critical evaluation of the reported research is provided to explicate the limitations of the research and possible directions for future research.

5.1 DISCUSSION OF KEY FINDINGS

The research findings in Phase 3 suggest that the interview analysis findings in Phase 2 are not an accurate representation of the actual situation in the case organisation: the presence of silo mentalities was challenged by the SNA findings; the lack of organisational slack was somewhat supported by the SNA findings; and a study on a SD ICT system failed to determine the effectiveness of an organisational SD ICT system because of a lack of respondent awareness. This is surprising considering the core barriers that emerged from the interview analysis aligned with existing KM research in the civil engineering field and are by no means unique to the case organisation. For example, Carrillo et al. (2004) identified these barriers after surveying senior managers in top UK civil engineering companies. Whilst each research activity has been independently discussed in either the preceding chapter or peer-reviewed articles, this section discusses at large the relationships between the findings and extant research and makes observations on their potential implications.

Aspects of the following discussion are reported in a peer-reviewed international conference proceeding (Appendix D).

5.1.1 Organisational Slack

The interview analysis indicates that participants feel their ability to share SD knowledge with their peers is heavily constrained by a lack of organisational slack. As discussed in Appendix B, organisational slack is a prevalent KS barrier in many industries. It has been especially recognised in the civil engineering related domains where the client-led culture discourages non-project activities (Fong, 2005, Egbu et al., 2003, Carrillo and Chinowsky, 2006). However, further investigation using

SNA found that this barrier may not be inhibiting the KS potential of the studied populations.

Research recurrently asserts that time is a crucial factor in developing and maintaining mutual trust, which is accepted to be a cornerstone of KS. However, large organisations typically exhibit complex environments that spawn time pressures, geographically dispersed staff, formalised hierarchical structures, and so on. Characteristics, such as these, were identified during the interviews and are typical in civil engineering related organisations. Consequently, members of such organisations are typically unable to dedicate a large proportion of time to maintaining their social networks (Cross et al., 2002a, Hansen, 1999). Despite the presence of complex environmental constraints and infrequent contact, the SNA findings suggest that organisational members continue to be successful in KS activities with their SD contacts.

Fong (2005) found that whilst complex organisational environments may restrict KS opportunities, they may also stimulate it through recognition of uniform work conditions. In such situations organisational members may recognise that they're subjected to similar constraints and are unable to engage confidence-building activities that contribute to the development and maintenance of mutual trust. Koskinen (2003) found that in project-oriented organisations a form of depersonalised trust emerges where organisational members refer to each other in terms of roles rather than individuals; Fong (2005) similarly found that members openly shared knowledge in project environments with little reference to trust. This implies that the notion of 'weak ties' may not be applicable to the studied populations as they exhibit similar characteristics to these previously studied populations. Levin and Cross (2004) introduce the concept of 'trusted weak ties' and 'reactivated strong ties' where relationships with organisational peers automatically instil a degree of trust or remain dormant until reactivated whereby tacit knowledge can be quickly shared and mobilised for purpose. Based on the SNA data, it is not possible to directly determine whether either tie-type is prevalent in the case organisation. However, the interview analysis does suggest that such novel ties exist; e.g., a number of KS enablers were widely reported regarding organisational members generally exhibiting behaviours that endorse an open communication culture, the need for KS, and positive attitudes towards SD.

Much research has been conducted to assess the effects of organisational slack, most of which provides little compelling evidence to whether it facilitates or inhibits organisational performance (Chiu and Liaw, 2009). In relation to the case organisation, it is clear that organisational members are interfacing effectively within the available slack time, which is believed to predominately comprise of their personal time. However, the interview analysis shows that participants believe they could generate greater SD value if they were provided with additional slack. Huysman and de Wit (2004) assert that it is possible that organisational members may use such additional resource less effectively, thus adhering to extant arguments that it is more beneficial to lean towards providing less slack rather than too much (cf. Leibenstein (1969, 1980) in Chiu and Liaw, 2009). However, it is also recognised that too little 'free time' may stifle knowledge creation; time is needed to allow individuals to reflect, challenge establish knowledge and devise solutions to problems (Payne and Sheehan, 2004). Therefore, a delicate balance must be struck and senior management must be willing to forego short-term gains over long-term outcomes (Sharfman et al., 1988); a complicated and difficult strategic manoeuvre in an industry with tight profit margins and during a period of global economic austerity.

Taminiau et al. (2009) propose that besides an overemphasis on project work, the absence of a proper KM system can also hinder the effective use of organisational slack; Burgess (2005) states "it is important that organisations send clear and consistent messages about the types of knowledge-exchange activities that they want to encourage, and provide adequate credit, recognition, and time for employees who engage in those activities", a perspective shared also by Chinowsky and Carrillo (2008). Therefore, without such systems it is likely some KS for SD activities are neither stable nor strategic, as Hew and Hara (2007) found in their study of KS in online environments. Stable strategic KS for SD activities may alleviate the abovementioned organisational slack constraints in a number of ways, in particular: helping senior management cultivate a culture where KS is an integral aspect of HRM practices (Carrillo and Chinowsky, 2006, Bellini and Canonico, 2008, Esmi and Ennals, 2009), thus proactively rationalising slack (Chiu and Liaw, 2009); and helping organisational members to concentrate on more strategic and productive relationships (Hansen, 1999). The latter of these enhancements could be underpinned by the SNA findings, which can help organisational members and leaders take a portfolio approach to considering the constellation of organisational

members and ties that are worth using organisational slack to develop and maintain (Cross et al., 2002a).

5.1.2 Silo Mentality

It has been established that SD cannot take place in isolation – knowledge must span organisational and geographic boundaries to arm organisational members with the knowledge and information they need to deal with SD's complex and integrated requirements. This was reflected in the systematic literature review which recognised that collaborative SD studies generally consist of KS between diverse parties. The interview analysis found that a lack cross-boundary KS is present, generating a silo mentality. This was unsurprising since the background literature review revealed that fragmentation is common in civil engineering related organisations; e.g. Carrillo et al. (2004) identified this as an important KM barrier. Yet again, the SNA results suggest this is a misconception; population respondents regularly reported cross-functional and -geographic SD relationships.

A symptom of the lack of cross-boundary KS is that organisational members often exhibit a poor awareness for SD knowledge and activities outside their functional and geographic vicinity. Again, the SNA results contradict this by revealing that respondents' awareness of their SD contacts' knowledge and skills is predominately good. The lack of awareness perception may stem from interactions that seek specific SD knowledge; but may not provide enough 'breathing space' to solicit a broader understanding of SD knowledge and activities within the participants' respective vicinity or social network. Furthermore, Evaristo (2007) concludes that cultural variations (e.g. between SGs or offices) provides opportunity for misunderstanding when sharing knowledge; therefore it is likely that more time is required to mobilise knowledge across boundaries (Goh, 2002). Consequently, the time booking system may exacerbate poor cross-boundary awareness by inhibiting organisational members autonomous KS, thus creating a lack of empowerment whereby members require authorisation to engage inter-functional and -geographical KS activities.

The interview analysis also found that the reward system disincentives cross-boundary KS, a widely recognised KS barrier (Riege, 2005); Szulanski (1996) asserts that a "knowledge source may be reluctant to share crucial knowledge … [as] it may resent not being adequately rewarded". However, the SNA results contest this finding as 'access to' and 'engagement with' cross-functional and -

geographic SD contacts are consistently the strongest measured relationship attributes. Whilst there is not enough evidence to determine whether organisational members hoard their SD knowledge, the SNA results coupled with the interview analysis suggest that members exhibit openness concerning SD matters. Furthermore, contrary to the interview analysis findings, the functional and geographic locality of SD contacts bears little significance on the awareness, access and engagement relationship attributes, suggesting effective exchanges; this is also contrary to extant researches which propose that exchanges become more troublesome with cognitive distance (e.g. Inkpen and Tsang, 2005, Koskinen et al., 2003, Hansen, 2002, Nooteboom, 2000). Therefore, these findings suggest that the reward system is not impeding altruistic behaviour by promoting self-interest (Deci, 1971, Deci, 1972). Cabrera and Cabrera (2002) refer to such situations as a 'public-good transformation' in which social cooperation dilemmas dissipate when the aim is to maximise collective gain; this theory predicts that the more an organisational member values the collective gain, the more likely they are to engage in the activity. As established earlier in this thesis, there is an increasing sense of urgency to adopt SD principles as our environment deteriorates, and that civil engineering related disciplines play a pivotal role in responding to such pressing concerns. As this threatens our most basic needs (cf. Figure 2.3), it is possible that this realisation drives positive attitudes towards KS and SD, as identified in the interview analysis, and motivates organisational members to engage in activities that create collective gains which go beyond their role and the case organisation itself. This conjecture corresponds with Huysman and de Wit (2004) who state that "people do want to share knowledge but only if there are good reasons to do so."

It was established earlier that SD requires an integrated approach to generate the greatest value. Thus, an alternate view is that organisational members recognise the need for greater formal integration across functional and geographic boundaries, as Bishop et al. (2008) found whilst studying "people-oriented factors that ensure the effectiveness of KM initiatives within construction organisations". Whilst the mapped social networks reveal a large number of ties that bridge functional and geographic boundaries, the interview analysis revealed that social networks were predominately used for knowledge seeking and impromptu KS. In light of the above discussion on striking a 'delicate balance' of organisational slack, it seems a reasonable conjecture that KS for SD exchanges occur on a 'need-to-know' basis. Lichtenstein and Hunter (2008) discuss this KS paradigm and found it to be an efficient use of time where only relevant knowledge is exchanged; they also

recognised that such approaches may create islands of knowledge. Margerum (2001, 2008) and Garde-Bentaleb et al. (2002), on the other hand, demonstrate that the explicit management of interaction between parties can improve collaborative outcomes.

Caution should be exercised when establishing formal integrated networks. Whilst complete integration may be considered the ultimate goal, it is not necessarily possible or desirable in practice. First, Hansen (1999) comments on the tight coupling between individuals, stating they "may constrain the inflow of new knowledge and inhibit the search for new knowledge outside the established channels, an activity that is likely to be more important in changing environments." Consequently, an overemphasis on integration may make the networks too rigid, thus defeating overarching goals and hampering innovation (Nooteboom, 2000). Second, the costs of integration could be significant and create tensions between parties (e.g. reward systems between SGs and offices); if not properly managed, such 'professional factors' could weaken the existing KS situation (Hansen, 2009, cf. Bundred, 2006). Finally, in large international organisations, such as the case organisation, it is not possible for organisational members to maintain cohesive social networks with more than a small proportion of individuals (Hislop, 2005). Whilst this may be perceived as a limiting factor, its acknowledgement can support the spread of KS responsibility and the cultivation of a KS culture.

5.1.3 Poor SD ICT Systems

It was established that ICT systems play a major role in mobilising SD knowledge and information (Mohamed et al., 2009). The interview analysis found that the case organisation's ICT systems do little to support organisational members in SD matters. In response an intranet-based SD portal was developed and made available to all organisational members. However, an evaluative questionnaire revealed that the SD portal is not widely recognised or used. Boddy et al. (2007) also found civil engineering organisations' hierarchical structure and bureaucratic nature often inhibit the successful adoption of KM systems.

A dominant challenge is raising and maintaining awareness of SD ICT systems. Despite publicising the portal via numerous communication channels, few organisational members have an awareness that the service exists. Beirne and Cromack (2009) point out, "the benefits that can be drawn from available technologies will be limited unless they are embedded within receptive and

appropriate social, cultural and organizational contexts". The interview analysis suggests that the case organisation's structure and culture often resist changes, whilst Carrillo et al. (2004) cited that employee resistance is a KM barrier in civil engineering related disciplines. Nonetheless, in a time constrained environment, it is a reasonable conjecture that organisational members are locked into an efficient pattern of working that hampers the seeking of new knowledge sources or improved work practices, thus preventing them from acquainting themselves with new technology.

The interview analysis also revealed the lack of organisational slack is preventing the maintenance of electronic content. Therefore organisational members are often sceptical regarding the validity of the information provided by existing organisational KS systems. Barnes and Vidgen (2009) assert that well maintained intranet systems will sustain user interest and future use whilst bolstering their usefulness and information quality, therefore quashing mistrust in content. As established earlier, SD knowledge is rapidly evolving and highly dynamic. It therefore requires that corresponding knowledge systems exhibit dynamic features otherwise they are likely to be abandoned because their content becomes unusable (e.g. the cost of re-using or searching for existing knowledge becomes greater than the cost of re-creating the knowledge) (Desouza and Awazu, 2005).

Although the interview analysis found that senior management are believed to be encouraging KS for SD, the IAM questionnaire findings suggest that senior management and overall organisational support is weak and are thus barriers to technology adoption. Three reasons may underpin this finding. First, senior management are unaware of the SD portal or its KS benefits, therefore are unable to advocate it. Second, senior management agree with the IAM questionnaire findings in that the portal lacks a clear purpose and aims, therefore not comprehending how it can add value. Third, the interview analysis clearly indicates that socialisation is the preferred KS approach; therefore, senior management may also perceive interpersonal KS to be a superior KS approach, especially as other organisational KS systems have historically fallen into decay. As established earlier, the interpersonal dimension continues to dominate in civil engineering related disciplines (Esmi and Ennals, 2009), where intranets and other KS systems are perceived as too cumbersome (Gluch and Raisanen, 2009). Interpersonal approaches to dealing with SD matters were also recurrently emphasised in the

systematic literature review (cf. Cooper, 2002, Measham, 2009). However, it is also acknowledged that ICT has great potential as an enabler of KS for SD. Nonetheless, if the benefits of the SD portal are to be realised, senior management support is needed to manage the abovementioned negative perceptions to cultivate buy-in from all organisational members.

5.2 RECOMMENDATIONS

Several practical recommendations follow from this work, whose aim is to satisfy the final overarching research objective. The first recommendation is to develop a change strategy that engenders a KS for SD culture. Whilst all of the following recommendations can be implemented independently, it is possible the latter three may emanate from or be embodied by the first recommendation of cultural change.

5.2.1 Cultural Change Strategy

The author believes the case organisation could benefit significantly from a strategic approach to cultivating a culture whereby KS for SD is the norm. Throughout the research, the author did not identify any overarching strategic agenda for how the organisation plans to leverage its knowledge to deliver increasingly challenging SD requirements or capitalise on its high-value knowledge. The absence of this agenda is believed to be a primary cause of haphazard, reactive KS for SD, as postulated above. It is proposed that a strategic approach would ease the organisation's typical civil engineering culture in favour of longer-term SD goals.

This strategy should aim to coordinate the entire organisation towards a 'superordinate' goal (Burgess, 2005), thus ensuring all MBFs and SGs share the same strategic vision and collaborate to achieve it. In doing this the case organisation must consider how its group-wide SD capabilities can be integrated to generate greater benefit, and how KS for SD can become seamlessly integrated into daily project-oriented activities (Bishop et al., 2008). To achieve this, the organisation must recognise that this requires a holistic change; minor alterations to existing processes and tools is likely to prove insufficient (Cross et al., 2005). Further, such changes should be tailored to fit with the organisation's culture (McDermott and O'Dell, 2001), thus made to work for organisational members.

As discussed in the previous section, senior management play a fundamental role in cultivating cultural change; they have the ability to provide strategy, resources, infrastructure, rewards, and so on (Mohd Zin and Egbu, 2010). Thus

senior management should champion the strategy and commit to driving forward the desired changes. To gain organisational buy-in and commitment, a value proposition must initially be devised; i.e. what is hoped will be achieved through more effective KS for SD (cf. O'Dell and Grayson, 1998). Whilst the research reported in this thesis may act as a initial guide to developing a value proposition, Perrin et al. (2006) propose that the CKO should consult organisational members to specifically ascertain the impact and urgency of the KS for SD issues; clearly the organisation's CKO will need to liaise with senior SD leaders throughout this process.

5.2.2 Reform Time Booking System

The above organisational slack discussion points to an opportunity for reform of the time booking system; an opportunity which seems prevalent in civil engineering related organisations. This would allow the case organisation to reconsider the importance of proactively managing members' slack time, thus transmitting a clear and consistent message about expected KS activity. Clearly, HRM will play a pivotal role in managing this holistic change; they will also be required to evaluate corresponding systems, such as rewards and recognition.

Should the benefits of this potentially radical change not outweigh the drawbacks, then greater transparency is needed for how the KM budget is to be used in relation to KS for SD. It is clear from the findings that organisational members feel that the KM budget is not being allocated in accordance with its purpose. Further, such funds should be allocated prior to their requirement; should members need to apply for access to this budget on a case-by-case basis, the inherent bureaucracy may inhibit timely knowledge exchanges which may prove detrimental to project performance. Management should solicit regular feedback from organisational members or use SNA techniques to recognise where this resource is best applied; e.g. to enable organisational members to actively engage through the SD portal.

5.2.3 Strengthen Social Networks

Whilst the mapped social networks revealed a good degree of cross-boundary KS, management should seek to reinforce or establish KS for SD relationships that are strategically significant. This could be achieved systematically (e.g. identify two suitable candidates who share a common characteristic) or more organically/

serendipitously (e.g. encourage members to network with peers from specific groups). Either way, it is recommended that to build effective, lasting relationships, organisational members should be provided with adequate time and a shared space (Nonaka and Konno, 1998, Davenport and Prusak, 2000).

Further, with full permission from respective organisational members, the identity of key players within the mapped networks could be released. This would allow management to solicit insights from these individuals to help recognise where KS for SD improvement opportunities exist. It would also allow management to ensure that key players are provided with adequate time to fulfil their multifaceted roles (Cross et al., 2002b).

5.2.4 Next Generation SD Portal

It was recognised that technology can enable KS for SD across the entire organisation. Whilst it is evident the SD portal had a number of shortcomings, the continued development of the second generation SD portal could provide a much improved service. Four aspects need particular attention:

- *Raised awareness* could be achieved by deploying a formal group-wide communication plan. This has many benefits that can help gain buy-in from all organisational members and overcome potential resistance to change (as discussed above) (cf. Mei et al., 2004). A communication plan addresses three communication aspects: the target audience; the message to be distributed to each target audience group; and the medium and frequency of communication (O'Neill and Adya, 2007). Further, senior management should champion this plan to signal the organisational importance and advocacy of the portal (Singh, 2008).
- *Increased usefulness* could be achieved by aligning content with common project requirements. This would allow users to quickly access knowledge and information that directly relate to their immediate needs. Extensive piloting and workshop feedback would ensure that this goal is successfully realised without further damaging trust in electronic resources.
- *Training and user support* should be provided to ensure all organisational members understand how it can help them in their project activities and that they possess the necessary skills to use the portal effectively. This could be delivered in a virtual manner, thus maintaining the sustainable ethos (cf. Pohl et al., 2009).

- *Intranet platform upgrade* would enhance how the portal enables KS for SD. Social platforms have many benefits, including: personal ownership; greater integration of content; and self-organisation (Coakes, 2006). The drawback is that it requires a significant level of investment.

It is recommended that the IAM questionnaire should be regularly recycled to ensure the portal is providing an effective and efficient service, and to evaluate whether any changes have been well received.

5.3 DIRECTIONS FOR FURTHER RESEARCH

This section considers further research that could be undertaken but was not addressed during the EngD programme. When dealing with any phenomenon that is, by definition, complex, a wide range of questions are likely to emanate that aim to build a richer understanding of the area under scrutiny. Whilst not all of these can be stated here, the author believes the following three further research activities would prove particularly insightful.

This thesis has attempted to focus on the enablers and barriers to KS for SD within the case organisation. To continue the explorative research in this area, the author proposed the use of qualitative system dynamics; unfortunately this research activity was not possible due to budget cuts in the case organisation. Swart and Powell (2006) present a systems based KM (SBKM) technique that captures knowledge requirements. This uses influence diagrams to map the variables in a system, the causal relationships between variables, the interested or responsible parties that are able to influence these relationships, and the knowledge and information required by these parties to fulfil their role(s). Elicitation could be achieved by conducting a series of facilitated workshop sessions (cf. Powell and Swart, 2005) or one-to-one interviews (cf. Howard et al., 2007); the SNA findings could be used to identify study participants based on their network position; and the above findings and discussion could be used as a platform to initiate discussions. This research would provide senior management with an abstract appreciation of how changes in KS for SD (e.g. an increase in organisational slack) may affect SD and organisational performance. Further, it would provide a knowledge map for

which an audit could be carried out to identify and close knowledge gaps[3]; and SNA could be used to audit the strength of ties between relevant parties in accordance with the SBKM model, thus ensuring the presence of strategic relationships.

The influence of senior management was recurrently visited in this thesis. Whilst the interview analysis found that senior management to be encouraging KS for SD, it seems they govern a culture which constrains, not enables, it. Further research is needed to understand how this situation emerged; e.g. do they recognise the value of KS for SD but are unsure how to cultivate a culture that embraces it, does their perception of KS align with the needs of project members, or under the current economic circumstances do they feel that KS for SD is a luxury that *cannot* be afforded?

Three widely accepted KS barriers were found not to necessarily be barriers in themselves. Clearly further research is required to examine this finding in other contexts; such contexts would need to believe that they're affected by the contested KS barriers. Whilst a corpus of extant research posits that these are actual KS barriers, most studies adopt a single-method research design; it is the author's belief that a mixed-method design may prove more revealing. This research should also account for the aforementioned complex organisational and professional factors as these may provide insight to the mechanisms behind the perception of KS barriers.

Finally, the systematic literature review (Appendix A) identified gaps in extant KS for SD research in civil engineering related disciplines, and thus opportunities for further research.

5.4 LIMITATIONS OF RESEARCH

A number of important limitations need to be considered in relation to the reported research. Whilst these were detailed within each research phase, some limitations overarch the research and need to be acknowledged.

The foremost limitation is that the research undertaken focused on a single organisation. Whilst this limits the external validity of the reported research, it

[3] The author began a SD knowledge and skills audit SD knowledge and skills in collaboration with the case organisation's internal SD leader. SD-oriented knowledge and skills in the organisation's dedicated database were grouped according to SD fields. This aimed to identify organisational strengths and weaknesses and recognise potential experts within SD fields. Unfortunately, it was not completed due to budgetary constraints.

should be noted that the case organisation is a large international group firm. Thus, the MBUs are considered a group of smaller organisations that reside under an umbrella group. This means that they exhibit distinct cultures and often operate independently of their neighbouring MBUs. Further, Karl Popper (cf. Magee, 1973) introduces the concept of 'falsification'. Flyvbjerg (2006) builds on this concept by asserting that single case studies are ideal because of their in-depth approach. Falsification is a rigorous test strategy whereby observations challenge axioms or propositions. This thesis achieves this by contesting a number of common KS barriers. It is therefore hoped that this will stimulate the need for further research.

The research also exhibits a large interpretive element, thus the findings and conclusions are subject to researcher bias and can thus be questioned. Other researchers may not derive the same interpretations from the collected data, it is unlikely that the researchers' worldviews are completely aligned, and thus different biases will almost certainly emerge. Further, as pointed out in Section 3.5, the collected data is likely to suffer from reliability issues. It is highly probable that neither the original researcher nor a different one would be able to replicate the collected data, and thus different meanings may be inferred.

Non-random purposive sampling underpinned two research phases. This was considered a useful way of collecting rich data from a diversity of sources in the area of study (cf. Dixon et al., 1987, Kumar, 2005). In both phases, secondary data was used to support the sampling criteria to avoid ill-conceived judgements. Nonetheless, it is prone to researcher bias as those sampled for study already met predefined criteria, and may raise concerns about the generalisability of the research.

CHAPTER 6
CONCLUSIONS AND IMPLICATIONS

The purpose of this final chapter is to present the conclusions that encompass all the work presented in this thesis and the implications of this work for the case organisation and wider industry.

6.1 CONCLUSIONS

The research reported here contests three widely cited KS barriers in the context of SD in civil engineering. Whilst researches frequently report *lack of organisational slack*, *silo mentality* and *poor ICT systems* as prevalent KS barriers, this research proposes that, in certain circumstances, the perception of such barriers may be superficial. This proposal is particularly interesting in the context of the civil engineering sector which is often perceived to be a laggard in KM, often failing to achieve the benefits of KS. In light of this, this research suggests that KS for SD is occurring in the case organisation and other civil engineering organisations.

The principal aim of this research was to investigate enablers and barriers to SD KS within the civil engineering sector and to identify opportunities for enhanced performance. A review of extant literature recognised that KS has the ability to significantly enhance SD performance, yet civil engineering organisations typically fail to practice effective KS. In response a mixed-method exploratory case study approach was applied that sought to learn which barriers and enablers hinder and enable effective KS for SD within civil engineering organisations. The findings of this research are founded on data collected from an international civil engineering consultancy, in which three research instruments were deployed to collect qualitative interview and quantitative questionnaire data. Interpretation of the combined findings revealed new insights to the perception of three typical KS barriers:

- The perception of a silo mentality may stem from a lack sufficient time or formal KS activities that limit awareness of SD activities that occur outside of organisational members' organisational and geographic vicinity. However, it seems organisational members are autonomously overcoming this, driven by the fundamental need for sustainability.
- Managing the balance of organisational slack is a common challenge in large organisations. In this instance, the lack of slack time is predominately believed

to be a result of a lack of clear strategy on which KS activities and SD knowledge take precedence; at present it seems KS for SD activities are neither stable nor strategic.

- Socialisation is recognised as the preferred KS approach in the civil engineering sector. This is believed to contribute to the perception of poor performing SD ICT systems, which seem to suffer from poor organisational awareness, senior management support and content maintenance.

It was also learnt that the case organisation exhibits a culture whereby KS for SD takes place in a reactive, haphazard fashion. It is believed this predominately stems from a projects-first mentality which requires organisational members to justify non-project related work activities; this culture is common throughout the civil engineering sector. Clearly, reactive KS for SD is unsustainable; SD requires an integrated approach which necessitates a proactive KS culture to deal with its complex, interdisciplinary nature. In relation to this, senior management (an aspect of KS leadership) is believed to wield the greatest influence to alleviate such cultural and HRM related issues predominately through greater upper management sponsorship and governance of KS for SD activities.

SD is almost certainly the most complex challenge the civil engineering sector has ever faced. It seems that much can be done to improve the way SD knowledge is shared and, thus, evolved. The need for this change is pressing and goes beyond economic viability: we have a finite amount of time to considerably reduce our impact on our planet before we cross the *environmental* Rubicon. Efforts to catalyse our knowledge and practice of SD can be underpinned by KS, yet organisations must be willing to embrace such concepts and their potential benefits; the systematic literature review demonstrates the little reported work that has been undertaken in this field. The subsequent remaining sections aim to help such organisations by emphasising the implications of this research.

6.2 IMPLICATIONS FOR THE CASE ORGANISATION

The research has provided the case organisation with an opportunity to improve its KS for SD. Using a multi-faceted explorative approach the organisation now has a richer understanding of the importance of intra-organisational KS for SD, their strengths and barriers in relation to KS for SD, and a set of recommendations to lower the identified barriers. These can now be addressed to deliver greater SD performance in an increasingly aware and competitive market.

It has shown that the organisation exhibits a number of KS enablers, including: an open and trusting knowledge exchange culture; cross-functional and -geographic KS; and members who recognise the benefits of KS and SD, as discussed in the preceding chapter. However, these benefits are inhibited by a number of barriers that seem to stem predominately from HRM practices. A set of recommendations have been provided that aim to help the case organisation lower these barriers. It seems clear that senior management buy-in is fundamental in overcoming delivering the recommended actions. Adopting the proposed recommendations will aid the organisation in cultivating a culture whereby KS for SD is the norm and perceived as an integral aspect of the organisation's strategic mission. Such changes typically take years to achieve (Cash et al., 2003) and consequently require firm commitment throughout the transition.

A series of social network maps have been produced that show the KS for SD connectivity within SGs. These maps enable the assessment of an individual's or group's exposure to SD knowledge and information, providing insight to connectivity issues and the location of key player types. Whilst this was only conducted in three populations, the quantitative approach and tools are repeatable. As socialisation is a preferred KS approach, social network maps can help to monitor the evolution of organisational social connectivity and to evaluate the success of socialisation initiatives.

An intranet-based SD portal has been established, the development of which was supported by the interview analysis. An assessment approach was agreed with the case organisation, with an initial evaluation of the SD portal indicating where it could be improved. This activity has provided a stepping stone for organising SD knowledge and information using the organisation's globally accessible intranet system.

Finally, the findings suggest that the perception of a problem is not always a problem in itself. Thus, asking direct questions may not paint an accurate picture of the area under study. Consequently, other organisational surveys (e.g. the annual staff survey) may benefit from a triangulation approach to ensure any subsequent improvement actions drive the desired results.

6.3 IMPLICATIONS FOR WIDER-INDUSTRY AND PRACTICE

Civil engineering related disciplines are under increasing pressure from clients and government to deliver sustainable systems. The research has established that in order to attain the goal of sustainability, organisations need to improve the way they manage their intra-organisational knowledge. It was found that most of the identified extant research paid attention to inter-organisational KS, despite some authors asserting that intra-KS should precede inter-KS (e.g. Mohamed et al., 2009). As such, the research has contributed to a small body of extant knowledge in the area of intra-organisational KS for SD in civil engineering.

This research raises a concern that it may be too easy to identify with ubiquitous KS barriers. Reviewed extant research suggests that only a small number of KS barriers are regularly identified; three of these were identified and explored in this thesis. The conclusion posits that these barriers may be perceived rather than actual. Thus, researchers should be attentive when labelling KS issues to ensure they truly reflect the studied phenomena.

The research has specifically reinforced the need for senior management support for KS. Whilst individuals may exhibit high-levels of motivation, they are often limited in what can be achieved within the confines of the systems in which they operate. Thus, senior management whom typically govern such systems are responsible for lowering or bridging barriers to enable individuals to capitalise on the knowledge of others for the greater good.

This research also demonstrates that simply providing a SD ICT system does not necessarily enable KS for SD. The IAM itself outlines a number of key factors that should be considered when developing and releasing an ICT system. Further, consideration must be paid to the context in which the system and its users reside (e.g. Daniel et al., 2003). An action research approach to developing SD ICT systems is advocated to embrace shifts in users' SD needs, although it was not possible to determine whether this proactive approach would enhance KS for SD.

Whilst most reviewed KS research adopts a single-method approach, this research used a mixed-method development approach, thus improving the validity and reliability of the research. The author believes this was valuable in exploring KS for SD in the case organisation as it allowed the research methodology to evolve

in light of new findings. It is hoped that the research process and outcomes presented in this thesis will encourage researchers to consider the benefits of adopting a mixed-method research design for richer insights to KS phenomena.

The reported research activities can be duplicated in other organisations for those who recognise the need for greater SD knowledge and information sharing. Ergo, this research may also act as demonstration for the insight which can be gained by adopting the research design and strategies. Further, this research represents an area in which little work has been reported, and therefore may act as a platform for future research efforts.

6.4 REFLEXIVE ACCOUNT

It is almost impossible for an ethnographer to divorce himself or herself from bias. As such, the purpose of this section is to explicitly identify and understand the dominant biases whilst briefly reviewing the EngD process. By doing this, one hopes to learn from the positive and less positive experiences of conducting this research in a bid to improve future research activities.

A number of noteworthy biases and lessons emerge from this research upon hindsight. First, my bias to conduct the qualitative research prior to the quantitative research unquestionably affected the research findings. The adopted approach meant I collected rich insights which did not specifically focus on these issues; the issues emerged from the exercise itself. I believe this somewhat led to the identification of the prosaic KS enablers and barriers. Nonetheless, this approach also allowed me to first recognise such common barriers were present and thus investigate their validity in a novel fashion.

Second, biases were also exhibited during the application of research methods. This is especially evident in the QDA activity. It is highly likely that my epistemological assumptions shaped how I navigated the interviews and inferred the responses. Whilst I consciously tried to move beyond the surface of this data to understand its underlying meaning, it is difficult to assess the success of this goal. In retrospect, I may also have used a more systematic quantitative technique to help alleviate the laborious monotony associated being “close to the data”; it could have acted as an accelerated starting point for focusing on dominant emerging topics. The conflicts between the QDA and SNA findings suggest that biases may have been introduced during the qualitative phase. This also raises the question of

whether the safety attribute (substituted for frequency) would have provided richer insight to the networks' dynamic. Similar biases were introduced in the systematic review during the exclusion process. Selected articles were predominately based on my personal perception of KS for SD, thus other researchers may have produced a different final set of articles.

Third, it may have proved more valuable to focus the research on small set of predetermined SGs with the aim of generalising the findings to the wider organisation. At times it felt like I was trying to consider the entire organisation's KS for SD needs; instead it may have proved more fruitful to identify a sub-set, research and implement KS for SD systems to fit their needs, and then gradually expand the scope of these systems to the wider organisation.

Fourth, as resource became increasingly constrained throughout the programme it may have proved more useful to the sponsoring company had I conducted the SNA at a higher level. This could be achieved by surveying the managers of each SG, asking them to nominate their best SD practitioners. These individuals would then be asked to complete the SNA survey, thus providing a more holistic picture of the SD connectivity between SGs.

As with much EngD research, this research was deeply embedded within a sponsoring company. This proved advantageous in many respects, chiefly because it allowed me to gain an understanding of the organisation's culture whilst enabling me to develop strong working relationships with key stakeholders. However, a number of drawbacks were also evident. Global economic instability had placed many businesses in financial turmoil. This clearly affected my research direction and impact; as aforementioned my research took many different 'turns' to ensure a comprehensive and novel research output was achieved and that the sponsoring company's expectations were met. One such example of this is the systematic literature review being conducted towards the end of the programme. Other drawbacks to this embedded scenario include: trying to distance myself from being perceived as an employee (i.e. limiting the level of non-research work); and me, the research engineer, residing somewhere between industry and academia (i.e. this can, and at times did, create a sense of isolation).

My personal feelings about KM and KS have also shifted over the past five years. At the outset of this programme I was frequently asked "What is KM and KS?" Whilst I tried to explain using textbook definitions and examples it often

seemed that my responses left my enquirers more confused than before! As my research evolved I found that my answer to such questions similarly evolved to reinforce the fact that you cannot manage knowledge and that you cannot force people to exchange knowledge. As a professional KM practitioner at the end of this research programme I find my answer now to be similar to: "I help people be aware of and gain access to other relevant and likeminded people and provide environments and mechanisms that encourage engagement in open and honest conversations with the general aim of improving their productivity".

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